98th Congress
2d Session

JOINT COMMITTEE PRINT

S. PRT. 45
98-1291

THE U.S CLIMATE FOR ENTREPRENEURSHIP AND INNOVATION

A STUDY

PREPARED FOR THE USE OF THE

JOINT ECONOMIC COMMITTEE
CONGRESS OF THE UNITED STATES

DECEMBER 28, 1984

Printed for the use of the Joint Economic Committee

U.S. GOVERNMENT PRINTING OFFICE
46-383 O
WASHINGTON : 1985

J842-14

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[Created pursuant to sec. 5(a) of Public Law 304, 79th Congress]

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LETTER OF TRANSMITTAL

DECEMBER 24, 1984.

To the Members of the Joint Economic Committee:

I am pleased to transmit a study on "The U.S. Climate for Entrepreneurship and Innovation." The authors are Dr. Robert Premus, former staff economist; Dr. Charles Bradford, assistant director and senior economist; George Krumbhaar, staff economist; and Wendy Schacht, Science Policy Research Division, Congressional Research Service. This study is based upon a series of Joint Economic Committee hearings on entrepreneurship and innovation, chaired by Congressman Daniel E. Lungren.

The study recommends a series of public policies to improve the Nation's overall climate for entrepreneurship and innovation. The central feature of these policy recommendations is that they are aimed at increasing risk taking, saving, and capital formation. The policy recommendations are industry neutral in that they "target the process of innovation," not specific firms and industries. An implicit assumption of the study, of which I am in total agreement, is that technological change and entrepreneurship are as important to the old, established industries as they are to the young, entrepreneurial companies.

The views expressed in this study are those of the authors, and do not necessarily represent the views of the authors' respective organizations, or the Joint Economic Committee or its members.

Sincerely,

ROGER W. JEPSEN,
Chairman, Joint Economic Committee.

FOREWORD

By Representative Daniel E. Lungren

In 1921, what has become the second longest running oil find in the United States was discovered at Signal Hill, CA. People attracted to the development of that oil frontier came from all parts of the country. Some of these "wildcatters," as they became known, struck it rich, others were not quite as successful. The one thing which they shared was a pioneering or risktaking attitude.

That entrepreneurial spirit which overtook Signal Hill has manifested itself in various forms throughout our Nation's history. It is symbolized by examples ranging from the covered wagon going west, the story of millions of immigrants who came to our country seeking opportunity, and the "flying contraption" invented by the Wright brothers, to the current technological revolution in various places around the country. Although the frontier today has shifted from land and oil to ideas and intellectual properties, the main actor, the entrepreneur, has continued to be the driving force. As history documents, an essential part of the American fabric has always been our country's ability to innovate. Additionally, one of our greatest resources has been the entrepreneur.

Entrepreneurs have often faced incredible odds in reaching their goals. The challenges confronting our Nation today are no exception. To some extent, the United States faces a different landscape than it did just a couple of decades ago. However, there is concern today that the American climate for the entrepreneur and for fostering innovation has not been all that it should be. Among more traditional labor, technical, and financial barriers, government policy has often stood as a significant hurdle. Unless we can foster entrepreneurship and innovation by removing policy and economic barriers we may risk losing our technological and economic lead. At stake lies the opportunity to maintain our country's technological leadership, improve our international competitiveness, and raise the quality of life and standard of living for our people.

Amidst the search for finding more productive ways of maintaining U.S. competitiveness, some have sought solutions from abroad. In the 98th Congress, the industrial policy proposal raised the issue of what the proper role of the Government should be in the economy. While this question was legitimate and important, the conclusions reached were misguided. The focus of the debate was on increasing central planning through an industrial policy board or bank, which was based partially on an erroneous assumption that Japan attained much of its economic success through its Ministry of International Trade and Industry.

Regrettably, much of the discussion over a national industrial policy has been too quick to look at the superficial success of other countries while neglecting our own strengths. This persistent "look over the shoulder" approach has led to what I call the "let's copy Japan, who first copied us" syndrome.

While we should never close our eyes to alternative approaches, we should not, at the same time, neglect what has worked successfully in the past. By disregarding our own economic and technological strengths, we allow other countries to develop ideas that originated in the United States. Thus, we allow the fruits of our ingenuity to slip through our fingers. The fact that the climate for the development and marketing of many of these ideas is better in other countries accounts for a large part of the problem. While there have been other centers of innovation, during the past quarter of a century, two primary regions have become recognized for spawning a technological revolution. They have become known as Silicon Valley and Route 128.

The growth in these two areas represents the merging of science and technology and the marketplace. Both regions illustrate what can happen when the fruits of basic research are used to create new technologies, products, and innovations. Regis McKenna, Regis McKenna Public Relations, described this development as it occurred in California:

> Silicon Valley is more than a place; it is a phenomenon . . . (It) is a symbol of innovation, growth, entrepreneurship, the prosperous future of high technology and the coming of the age of information . . . (Silicon Valley) is educating the rest of the world on how to survive in the 21st century.

As part of the inquiry into the process of innovation and entrepreneurship, the Joint Economic Committee held four days of field hearings in Sunnyvale, CA, and Boston, MA, to look at the Silicon Valley and Route 128 experience. These hearings represented the first attempt to analyze, comparatively, the entrepreneurial environment in the Nation's two premier high-tech centers. The primary concern in these hearings was to examine what guidance for public policy is held in the phenomenal success of Silicon Valley and Route 128.

As the report elaborates, there are a confluence of factors which can be identified as integral to the development and success of both Silicon Valley and Route 128. Making up part of the infrastructure to spur and support the process of innovation in these areas are the educational, marketing, mobile labor supply, management, and skill base. Among others, the importance of role models and access to venture capital were cited as critical factors.

Admittedly, inclusive among these factors was an element of randomness. A couple of witnesses suggested that perhaps the primary reason behind the geographic location of these two centers was attributable to historical accidents. Dr. Robert Noyce suggested that the base for Silicon Valley was established because the inventor of the transistor, William Shockley, grew up in Palo Alto. George Kariotis, former Secretary of Economic Affairs in Massachusetts, attributed, in some part, the development of Route 128 to happenstance.

While this report notes, and each of these witnesses suggested, that there is more to explaining the Silicon Valley and Route 128 phenomena than happenstance, this random element cannot be entirely overlooked. Indeed, it raises some valuable insights for public policy. What it suggests is that as a policy premise government should not target *specific* industries or areas. But the presupposition that government policy should not specifically target does not by any means imply that there is not a role for the Government to play in fostering economic and innovative growth.

The testimony made it clear that the Government can interpose barriers as well as incentives which affect the process of innovation. Perhaps the best support for this contention can be found in the experience with modifications in the capital gains tax rate. Going back to 1969, the data clearly show that when the capital gains tax was increased, access to venture capital—essential to new enterprise development—dried up. The exact opposite resulted when the capital gains tax was reduced. For example, since the decrease in the rate resulting from the Economic Recovery Tax Act in 1981, new jobs, accelerated applications of new technology, an enhanced environment for innovation, and increased revenues have all resulted. In addition, 1983 was a record year for venture investment, largely due to the reduction in the capital gains tax.

The economic growth, increase in jobs, and greater revenues all argue for retention of a differential between the capital gains tax and treatment of ordinary income. This is a proposal which the Congress would be wise to heed in the debate on tax simplification.

Thus, while not directly targeting individual firms or selecting certain industries, government policy, by fostering a favorable environment, can either serve as a barrier or incentive to economic and innovation growth.

What then is the proper role for government? What conclusions or guidance for public policy can be suggested? First, a major emphasis of this report is that promoting economic growth is best achieved by fostering a competitive environment, *not* through attempts to plan or target the economy. An apt analogy was offered in testimony by Dr. George N. Hatsopoulos, Chairman of the Board of Thermo Electron Corporation. As he pointed out during the Boston hearings, a cloud chamber, which is used by physicists for experimental purposes, establishes an environment in which condensation results. One never knows precisely where the condensation, which is triggered by a particle, will occur. What is important, however, is that once the favorable conditions are established, the desired goal, while perhaps not always immediately obtainable, will result.

By contrast, it seems all but certain the Government would have failed if it had tried to plan a Silicon Valley or Route 128. However, both of these technology centers did benefit from the consequence of many government policies.

The lesson from these experiences as we head toward the 1990's is therefore clear. In direct contrast to central planning or targeting, government policy should instead focus on establishing favorable climate for innovation and entrepreneurship. By concentrating on the economic fundamentals and establishing a positive economic environment, we may not know precisely where entrepreneurship will be spurred or where the latest breakthrough will result. But without the environment for innovation and entrepreneurship, the risk, even for the risktakers, becomes almost prohibitive. Consequently, there is less of a likelihood that a flourishing of talents and spinoff of ideas will emerge.

Second, there was no doubt from the hearings held in Washington, Sunnyvale, and Boston that the "secret to success" in the process of innovation and entrepreneurship is people. However, too often in the past "the people factor" as it relates to economic growth is ignored in the committee and meeting rooms in Washington. Instead, the discussion of macroeconomic theory, while important, neglects the essential role of the individual. There is little doubt that our country has the resources and the ability to maintain our technological leadership. However, to preserve our competitive edge we will have to focus on policies which bring out the best in the individual or entrepreneur. Overlooking "the people factor" would be a grave policy oversight. To this end, the report advocates an incentive-based approach. Various incentive-based policies are explored, including a clarification and simplification of incentive stock options which permit many employees—including those at the lower and middle levels—to share in the benefits of their firm's success.

Third, it became clear from the hearings and tours of companies that if there is any single area where Japan has an advantage over the United States it in manufacturing. There is little disagreement that our Nation still leads in the area of innovation. The consequence of this, however, is that many of the ideas originating in the United States are developed in Japan since the Japanese have proven better in the past at packaging and marketing the product. In order to retain the fruits of our ideas, the United States will have to become more competitive in the manufacturing side of the equation.

Finally, government should not insulate companies from their own failures. As George Gilder has recently written "the knowledge—of inventors, entrepreneurs, producers, and consumers—which accumulates through the ongoing waves of human experience is the most crucial curve and capital of industrial progress. . . . Knowledge grows even when profits fall; and when profits rise, the learning process accelerates as entrepreneurs buy new experience by further investment and experiment." These views were echoed in the testimony of Dr. C. Lester Hogan, director and consultant to the president of Fairchild Camera & Instrument Corp. He indicated that as successful as Silicon Valley is perceived technologically, " . . . fewer than 5 percent of the entrepreneurial companies founded in Silicon Valley succeed. . . . it would be a terrible mistake for our government to attempt to save the 95 percent that fail."

Thus, from the seeds of the economic forces and government policy established throughout the past 25 years, the United States has been able to lead the world in the greatest technological revolution known to man. The consequence of policy today will impact the economy, jobs, quality of life, and technological leadership of our country as we enter the next century. The policy prescriptions suggested in this report offer some valuable suggestions for the outcome of each of these variables.

EXECUTIVE SUMMARY

The vital role played by the entrepreneur in economic growth and technological innovation is stressed in this study of the Nation's overall climate for entrepreneurship and innovation. In particular, the study examines how public policies impact the entrepreneurial process in America, and what the Government's role should be in fostering an improved environment for economic growth and technological innovation. A basic conclusion of the study is that many of the shackles that stifled entrepreneurial activity in the past several decades have been removed, at least partially. As a result of a vibrant entrepreneurial community, America is now experiencing an economic rejuvenation in its old and new industries. The entrepreneurial expansion is broad based and can be found in the service as well as the manufacturing industries.

Entrepreneurs are defined to include all risktakers in society who have the organizational skills and the means to assemble the resources and the technology necessary to exploit new economic opportunities that are not generally apparent to other decisionmakers. Risk bearing, organizational skills, and foresight are the key attributes of entrepreneurs.

Entrepreneurship cannot be taught but it can be nurtured by public policies that improve the climate for innovation. Some recent public policy changes that are contributing to the current climate for entrepreneurial activities are:

1. An expansion of venture capital and other forms of risk capital resulting from recent public policy innovations. The 1978 and 1981 capital gains tax reductions, revisions in regulations governing pension fund investments, and improvements in Securities and Exchange Commission regulations governing access to private and public equity capital, contributed substantially to improve availability of risk capital.
2. A complete turnabout in inflationary psychology in recent years from one of high inflationary expectations to one of low inflationary expectations.
3. The deregulation of domestic industries such as trucking, financial services, communications, and the airlines, resulting in many new entrepreneurial opportunities.
4. Improvements in patent regulations to encourage technology transfer from Federal Government funded basic and applied research.
5. A greater emphasis on technology transfer from research in Federal Government laboratories.
6. A lower tax burden resulting from the Economic Recovery Act of 1981, including lower personal and corporate tax rates.

7. A shift in emphasis away from shortrun macroeconomic policies toward a goal of stable growth in aggregate demand, to reduce policy uncertainty and promote overall stability in the economy.
8. The restoration of strong Federal Government support for basic research.
9. The continuation of open trading policies with the international trading community.

While these policies have helped to stimulate economic expansion in the economy, the job is not complete. The current challenge is to (1) continue the policies that are in place and working, (2) eliminate or improve the policies that are in place but are not working, and (3) initiate new policies to overcome remaining technical, labor market, and financial barriers to economic growth and innovation. Some of the important remaining barriers to entrepreneurial expansion include:

1. A high Federal deficit which is diverting capital market funds that could be used to finance entrepreneurial investments.
2. An underutilization of universities and government labs as agents of technology development and transfer.
3. The excessive use of direct loans and tax incentives to attract industry by State and local governments. State and local governments have pushed aside many constraints to entrepreneurial expansion, but their continued emphasis on job pirating is counterproductive from a national viewpoint.
4. A Tax Code that has become increasingly complex and unfair, resulting in distorting influences on saving and investment decisions.
5. An antiquated antitrust law system which makes it difficult in some cases for American firms to compete internationally.
6. A growing sentiment in America for protectionists measures such as tariffs and quotas.
7. An inadequate patent and copyright protection system for the inventor/entrepreneurs of society.

As a result of these entrepreneurial barriers, the American economy is suffering from a comparatively low rate of saving, capital formation, commercial R&D, and industrial innovation. A basic thesis throughout this study is that a multipronged policy approach is needed to address these and other deficiencies in the U.S. climate for entrepreneurship and innovation.

STUDY METHODOLOGY

Many studies of economic growth are narrowly focused on the economic growth aggregates such as capital formation, labor supply, and productivity growth. Considerable emphasis has been placed in these studies on the relative contribution of the factors of production to growth in real per capita output. This study is less concerned about tracing an equilibrium growth trajectory for the economy. Instead, it focuses on the process of economic growth and on the role of the entrepreneur in combining capital, labor, and technology to exploit new economic opportunities. Equilibrium is never achieved in a dynamic entrepreneurial economy because the very entrepreneurial acts that propel the economy toward a new equilibrium also move the economy to a different plateau, or they interject new elements of disequilibrium into the analysis.

Growth in output, capital, labor, and technology are outcomes of the "process of innovation," rather than objectives to be achieved by economic policy. The role of government envisioned in this study is one of creating a climate for innovation so that the entrepreneurial process—the free market economy—can work efficiently.

An important assumption of the study is that free, unfettered markets ought to be relied upon to allocate resources and output of the private sector economy. This condition requires that government not impose its investment criteria in those sectors where the private sector is doing a good job.

Risktaking and innovation receive particular focus in this study because the entrepreneur as a bearer of risks and as an innovator is critical to economic growth in a dynamic economy. For this reason, the main focus of this study is on the process of innovation in which the entrepreneur is seen as the primary catalyst for long-term economic growth.

Innovation is a process that occurs in old and new industries. It undergirds and strengthens the basic foundation upon which economic progress depends. Innovation occurs in the public and private sectors and in the manufacturing and nonmanufacturing sectors. It results from the application of new ideas to organizing economic relationships and solving economic problems. Above all, innovation is a process of economic change; it is not the outcome of economic change. Indeed, an innovation policy is one that should emphasize a "level playing field" upon which entrepreneurs compete to achieve desirable outcome.

Much of the information in this study is based upon an analysis of a series of 1984 Joint Economic Committee hearings—including field hearings in the Silicon Valley and the Route 128 region—on the Climate for Enterpreneurship and Innovation in the United States.[1] These hearings, chaired by Congressman Daniel E. Lungren, examined the role of technology in the economy from the perspective of the entrepreneur. The purpose of the hearings was to identify the major incentives and barriers to entrepreneurship and innovation in the United States.

The analysis begins by discussing the evolving nature of American capitalism. In the past decade or so, the American economy has undergone dramatic structural adjustments. As a consequence, today's economy is different from the economy of the late 1960's and 1970's in that it is more: (1) energy efficient, (2) international, (3) service oriented, (4) technologically sophisticated, and (5) internationally competitive.

Not only has the structure of the American economy changed; the entrepreneurial character of the economy has changed. One consequence of increasing global competition, shorter product cycles and the emerging high-tech sectors has been an increased emphasis on product quality, service, and improved process technology in business planning. American businesses have shifted from shortrun concerns, such as stock prices, to longrun considerations such as market position, the role of technology, and dynamic competition.

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[1] U.S. Congress, hearings before the Joint Economic Committee, "Climate for Entrepreneurship and Innovation in the United States." Part 2. 2d sess., 98th Cong., Government Printing Office, Washington, D.C., 1985.

POLICY RECOMMENDATIONS

The policy recommendations of this study are based upon an extensive analysis of the relationships between government and the entrepreneurial community. An important assumption throughout the analysis is that government cannot and should not attempt to direct entrepreneurial activities in the economy. Rather, because government expenditure, tax, and regulatory policies impact on the entrepreneurial process, creating an improved climate for entrepreneurship and innovation is rightfully the responsibility of national public policy.

The policy orientation of this study is long run. The study is concerned with the process of growth and development of the American economy, and with identifying the appropriate Federal role in promoting an improved climate for entrepreneurship and innovation.

It is important to note that the private sector cannot work efficiently without government, because the Government performs many functions that are vital to the entrepreneurial process: research, defense, macroeconomic management, social policy, maintaining a legal framework, and trade policies are examples of government inputs into the entrepreneurial process. It is equally important to note that if government oversteps its bounds in carrying out its proper functions in dynamic capitalism, market inefficiencies will occur and economic growth will be impaired.

The policy recommendations of this study are grouped into the following categories: capital formation, commercial R&D, entrepreneurial policies, human capital, university linkages, technology transfer, new Federalism policies, and domestic and international competition.

Capital Formation

Capital formation occurs when investors invest in new plant equipment. In an environment of investment growth, technological innovation is stimulated. It is generally easier to incorporate new technology into new machines and physical facilities than it is to upgrade existing technologies and plant and equipment. For this reason, an accelerated rate of capital formation stimulates entrepreneurial demand and demand for new products and process technologies.

The study recommends the following government actions to raise the overall rate of capital formation:

1. *Remove or reduce the burden of double taxation of saving and investment.*—The current Tax Code offers a number of incentives to increase saving and capital formation. Individual Retirement Accounts (IRA's), accelerated cost recovery, investment tax credits, and lower marginal tax rates (the maximum rate is currently 50 percent) are all credited with contributing to the strong investment climate in the United States in recent years. Nevertheless, public

policy uncertainties, the large Federal deficit, marginal tax rates that are still too high, and high real interest rates remain as barriers to capital formation.

To remove these barriers to capital formation the study recommends:

2. *Monetary and fiscal policies that avoid shortrun fine tuning and place major focus on long-term economic growth.*—Removing policy uncertainty is an important factor in stimulating capital formation and innovation. This is because the most significant single factor encouraging or inhibiting entrepreneurship is the health and predictability of the macroeconomy. An economy characterized by large swings in aggregate demand does not provide the entrepreneur with a stable growing market that is conducive to new business growth.

3. *A gradual reduction in the Federal deficit to reduce real interest rates and allow the value of the dollar to find its longrun value.*—To reduce the deficit, the study recommends a longrun strategy of holding Federal Government expenditures to no more than 18 percent of gross national product.

4. *Lower marginal tax rates through tax base broadening.*—A modified flat-tax rate program could provide a significant stimulus to overall capital formation. The 1981 and 1982 tax programs made a significant step forward in reducing excessive taxation on capital investments, but they introduced differentials in effective corporate tax rates by type of investment. Tax base broadening would reduce the distorting effects of differential tax rate burdens. By lowering tax rates, overall capital formation would be stimulated.

5. *Expand the current IRA program to allow individuals to defer a larger amount of their otherwise taxable income.*—Increasing IRA exemptions to $5,000 per household would go a long way toward removing the heavy burden of double taxation on saving and allow the market to increase the Nation's rate of capital formation.

Commercial R&D

The Federal Government should pursue policies to encourage commercial R&D, but it should avoid substituting government "targetted" strategies for reliance on market signals. Maintaining a healthy basic research community, providing incentives for commercial R&D, and improving linkages between basic and applied research activities can provide a viable alternative to direct government involvement in commercial research. It should be noted, the private sector will not invest optimally in applied research unless inventors are given adequate patent protection and other problems of nonappropriation are overcome. Appropriation problems result in a divergence, at the margin, of social and private benefits resulting from research. When this occurs, the market will fail to optimize investment and research opportunities.

The study recommends the following actions to encourage commercial research and technological innovation:

6. *The Federal Government should maintain strong support for basic research at American universities.*—Since basic research precedes applied research, maintaining strong Federal Government support for basic research is important. Technological innovation

relies heavily on the progress and findings of basic research. Notwithstanding that basic research is becoming more and more valuable to commercial firms in its original form, it is still relatively long term in its scope. The traditional Federal role in supporting basic research, therefore, needs continuing support. The current Administration and the Congress have placed increasing emphasis on basic research, at a time when other budget increases are being curtailed. This priority on basic research is well placed, and will help keep this nation at the forefront of world technology.

7. *Congress ought to make permanent the current R&D tax credit and extend its base to include software development important to the application of technology within firms.*—At the present time, the R&D tax credit is not applicable to computer software R&D. This serious omission needs to be corrected if the R&D credit is retained in its present form. Additionally, the credit makes a distinction between the purchase of equipment for a university for the purposes of research, and for teaching purposes. Since this distinction is often impossible to make, and since there is a close correlation between a university's teaching and research missions, this distinction should be eliminated.

8. *Preserve the tax advantage of R&D partnerships, particularly when they are used to encourage joint research efforts.*—The growth of R&D partnerships has been a significant vehicle for raising the level of commercial research in the United States. Also, as will be discussed later, the R&D partnership approach has promoted technology transfer and collaborative research efforts between industry and academe.

9. *Efforts to adopt antitrust laws to current economic realities need to be continued.*—The study applauds the current Administration and the Congress for their efforts in adapting the enforcement of antitrust laws to modern conditions. However, changes in the basic antitrust legislation are needed. The Sherman, Clayton, and Federal Trade Commission Acts, which still comprise the Nation's basic antitrust legislation, were signed into law more than 70 years ago. Last year, the Congress passed the National Cooperative Research Act. This law made substantial improvements in the climate for industrial basic research, by clarifying the standard for competing firms so that they could benefit collectively from cooperative research. That law, however, was part of a broader proposal, the National Productivity and Innovation Act, which would also have removed barriers in the patent laws, among others. Additional attention needs to be given to refining these proposals in the 99th Congress.

Entrepreneurial Policies

An overall strategy to increase economic growth through stimulating saving, investment, and technological innovation ought to be accompanied by policies to facilitate structural changes within firms and among industries in the economy. For this reason an economic growth strategy ought to incorporate among its components an entrepreneurial policy.

Entrepreneurial activities flourish in a time of economic change. Indeed, they are the internal mechanism by which the economy is transformed and shaped by changing external and internal forces, such as international competition, technological change, and changes in consumer preferences. Providing an environment whereby capital formation and technological innovation are flourishing, as discussed, is the most significant action government can take to improve the overall entrepreneurial climate.

Nevertheless, beyond these policies a number of additional initiatives would be helpful:

A significant proportion of entrepreneurial activities consists of seeking technological opportunities that others overlook or fail to fully recognize for their full commercial potential. A strong Federal commitment to basic research in the advanced sciences, discussed previously, is necessary to create new high-tech entrepreneurial opportunities.

Entrepreneurial high-tech opportunities are too risky for institutional investors to consider, but fortunately, venture capital markets have expanded to fill the void caused by the increasing institutionalization of financing markets. A recently published JEC study on "Venture Capital and Innovation" found that networking and the availability of venture capital is a significant factor in the overall climate for technological innovation. Both the number and quality of high-tech entrepreneurial deals were found to increase as a result of expansion in venture capital following the 1978 and 1981 capital gains tax reductions.

Because of the importance of venture capital and others forms of risk and investment capital to the entrepreneurial process, the study recommends the following actions:

10. *Preserve the capital gains tax differential in the Tax Code to encourage risktaking.*—The Kemp-Kasten bill would provide this needed incentive while at the same time it would greatly simplify the Tax Code and lower marginal tax rates on income. For these reasons, the study recommends the adoption of the Kemp-Kasten program and it rejects the Treasury plan and the Bradley-Gephardt plan as they now stand.

11. *Improve incentives in the Tax Code to help entrepreneurial companies attract needed talent.*—Being able to attract talent is the number one problem of high-growth, young entrepreneurial companies. To overcome this problem, the study recommends changes in incentive stock options as an inducement to entrepreneurial growth. Specifically, the ceiling, sequencing, and tax preference provisions should be eliminated or modified.

12. *Also, the tax exempt status of employee educational fringe benefits should be maintained in the Tax Code.*

Human Capital

The progress of science and technology, and its potential for improving our standard of living, depend in the first instance on a society willing to invest in the human resources that underlie our technological preeminence. Yet the state of today's science and engineering education, starting at the secondary school level, leaves much to be desired. Some have proposed a new Morrill Act. Other, less sweeping, proposals call for higher standards in the teaching of science and mathematics in secondary schools, and changes in the treatment of gifts of equipment for teaching (see above). The study notes that the current Administration and the Congress have placed special importance on the upgrading of basic science and math skills in the primary and secondary schools and in the university system. These efforts to improve human capital should be continued and reinforced with new initiatives that:

13. *Provide scholarships and other incentives for brighter students to enter the science and engineering fields in college and beyond.*

14. *Establish a nationwide program to make nonsubsidized loans available to all college students without regard to family circumstances.*—The principal and interest would be collected by the IRS through withholding when the loan recipients enter the labor market.

University Linkages

The Federal Government ought to pursue policies to encourage and promote stronger linkages between academe and industry. Policies in place that are already encouraging these linkages include preferential tax treatment of R&D partnerships, granting universities title to patents resulting from federally funded research, NSF funded university research centers, the inclusion of 65 percent of contract services with universities in the incremental R&D tax credit base, and tax deductions for equipment grants to universities for purposes of research.

The study recommends that these policies be maintained and the following few initiatives be implemented:

15. *Extend the R&D tax credit for contributions of equipment for the teaching of science in universities, colleges, and vocational schools.*

16. *Encourage Federal departments and agencies to engage in collaborative research with universities and industry.*—The collaborative performance of the basic research needed to support Federal department and agency mission requirements could lead to the emergence of "centers of excellence" within academe, strengthen the Government laboratory system, and speed the commercialization of new technologies.

17. *Encourage joint university-industry research through a continuation of preferential tax treatment of R&D partnerships when the university is a partner in the joint venture.*

Technology Transfer

Federal Government laboratory research is legally available for use by the public. In practice, however, there are few incentives to utilize Federal patents and other research findings. This stems from certain provisions of patent laws, and the large amount of resources required for tracking and following through on Federal research.

Under the mandate of the Stevenson-Wydler Technology Innovation Act of 1980, Federal laboratories have made significant efforts to inform the public about developments in their research programs. However, for the most part, technology developed in Federal laboratories remains underutilized in the private sector.

To improve technology transfer, the study recommends the following:

18. *Decentralize authority and responsibility for technology transfer by making technology transfer a Federal laboratory responsibility, subject to review by Federal departments and agencies.*—The study recommends that the Office of Research and Technology Applications be a full-time staff position, with responsibility for networking with the business community, defining conflict of interest rules, acting as legal council for laboratory employees, and establishing policies for rewarding employees for successful technology transfer programs.

19. *Establish a Commission for Technology Transfer to develop operating guidelines and procedures for laboratory directors, engineers, and scientists to work collaboratively with universities and the private sector.*

20. *Federal Laboratory Consortium—a voluntary association of Federal laboratories—should be designated as the primary coordinating organization for promoting technology transfer.*

New Federalism Policies

In recent years, State and local governments have made encouraging strides in reorienting their development strategies to focus on the process of innovation. Many States are changing their tax, regulatory, and expenditure policies to encourage entrepreneurial activities and technological innovation. This revamping of development practice is largely in response to competition pressures among the States and regions for economic development and jobs.

The study recommends a Federal Government "hands off" policy with regard to the design and implementation of State and local development programs. However, the Federal Government has a role in discouraging those State and local activities that detract from the Nation's overall climate for entrepreneurship such as job pirating and industry locational subsidy schemes. Industrial development bonds are frequently used as locational inducements at the State and local levels.

To overcome this deficiency and to encourage State and local governments to focus on the process of innovation, the study recommends the following:

21. *Discourage the use of industrial development bonds by eliminating their tax-exempt status.*

22. *The New Federalism policy of consolidating block grant funds and returning responsibility for regional economic development to the States ought to be continued.*—The Federal Government ought to maintain financial responsibility for those programs such as welfare and training displaced workers, in which there is a national interest.

Domestic and International Competition

Finally, because competition among firms and industries is vital to the entrepreneurial process, and the economic growth and prosperity of the Nation, a vigorous policy to promote competition, at home and abroad, must receive top priority in the decades ahead. In particular,

23. *The deregulation of domestic industries should remain as a national economic goal.*

24. *Open and free trade policies ought to be strongly supported and fought for by the Administration and the Congress.*

25. *Efficiency in the granting of export licenses must be improved so that American firms can get an early start in competing in international markets.*

26. *Foreign nationals with skills in occupations where there are shortages should be allowed to remain in the United States for a time.*

CONTENTS

Page
Letter of Transmittal III
Foreword—Representative Daniel E. Lungren V
Executive Summary IX
1. Introduction 1
    Structural Adjustments and the Entrepreneur 1
    Study Outline 3
    Study Recommendations 3
II. U.S. Economic Change, Economic Growth, and Innovation 6
    Longrun U.S. Economic Performance 6
    Is the United States Losing Its Competitiveness or Deindustrializing? 7
    Labor Force and Man-hours Worked 11
    Productivity 12
    Saving 13
    Improvements in the Productivity Environment 15
    Technological Innovation 16
    Research and Development 17
    Supply of Scientists and Engineers 21
    Patents and Antitrust Laws 24
III. University-Industry Collaboration 27
    The Emerging Role of Academe 27
    The Potential of University-Industry Collaboration 29
        Common Interest 31
        The Public Interest 32
        Traditional University/Industry Roles Are Changing 32
        Research Setting Generates Entrepreneurial Ideas 32
        Universities Assist Startup Firms 32
        Universities Can Leverage Corporate Research Budgets 33
    Barriers to University-Industry Collaboration 33
    Conclusion: How Can We Maximize the Benefits? 35
    Implications for Federal Policy 38
IV. Government Laboratories and Economic Development 41
    Nature of the Issue 41
    Technology Transfer Defined 43
    The Federal Interest 43
    The Transfer Process 45
    Current Federal Activities 46
    Improvements to the Transfer Process 48
    Summary and Recommendations 51
V. State Innovation Strategies 54
    Creating a Climate for Innovation and High Technology 55
        Locational Determinants 56
        The Role of Universities 57
    Creating an Investment Climate 58
        Cut Redtape 58
        Cut Taxes 60
        Offer Financial Incentives 60
        Improve Community Attitudes 61
        Train Labor 61
        Reduce Lost Time During Inspections 62
        Improve Cultural/Recreational Amenities 62
        Procure Resources From Local Businesses 62
    The Experience of Utah, North Carolina, and Pennsylvania 63
        Utah 63

        North Carolina 65
        Pennsylvania 66
    Summary and Conclusion 67
VI. Voice of the Entrepreneurial Community 69
    Risk 69
    Innovation and Creativity 70
    Role Models 71
    Employee-Management Relations 71
    Innovation and Work Environment 71
    Venture Capital Community 72
    Federal Policy and the Entrepreneur 73
        Capital Gains Tax 74
        The R&D Tax Credit 74
        Incentive Stock Options 75
    Conclusion 77
VII. Summary and Recommendations 79
    Summary 79
    Policy Recommendations 83
        Capital Formation 84
        Commercial R&D 85
        Entrepreneurial Policies 86
        Human Capital 87
        University Linkages 87
        Technology Transfer 88
        New Federalism Policies 89
        Domestic and International Competition 89
Bibliography 90

THE U.S. CLIMATE FOR ENTREPRENEURSHIP AND INNOVATION

By Robert Premus, Charles Bradford, George Krumbhaar, and Wendy Schacht*

I. INTRODUCTION

In his 1985 inaugural address, President Reagan emphasized that a "new industrial revolution" is in store for America. The one caveat is that the Federal Government must pursue the appropriate policies, including tax reform, to unleash the latent entrepreneurial energies within the American economy.

This study outlines the necessary set of public policies if the "new industrial revolution" is going to be more than a dream. The entrepreneur is at the centerstage of the growth-oriented public policy approach outlined in this study. The policies that are proposed are aimed at improving the Nation's overall climate for entrepreneurship and innovation.

STRUCTURAL ADJUSTMENTS AND THE ENTREPRENEUR

The American economy is undergoing dramatic structural changes, but change is not a new phenomenon. We have seen our society evolve from an agricultural economy in its first century to a heavy industry-dominated economy in the second century, and now we are witnessing a shift to a service-oriented and high-tech information society.

One consequence of an information-intensive economy is that manufacturing jobs, while continuing to grow in numbers, will shrink as a percent of total employment while service and high-tech jobs will expand in their share of total jobs.

In adjusting to the shifts, however, attention must not be limited to the high-tech industries or to the old, mature industries, nor should the public policy debate be cast in terms of the services versus manufacturing industries. High-tech, services, and manufacturing industries alone cannot generate enough jobs to make up for the jobs that will be lost as a result of dynamic adjustments in the economy. Rather, the debate should focus on the entrepreneur and a broad range of public policies to raise the rate of technological innovation, capital formation, and human resource investments.

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Structural shifts in the U.S. economy are necessary to improve competitiveness and economic efficiency. Without dynamic structural adjustments, the American economy will grow below its potential as a result of being "locked into" an inefficient industrial structure. Accordingly, government policies and business practices must be accommodative, not roadblocks, if we are to achieve rising living standards, and improved international competitiveness. In fact, the structural shifts are the basis of a new burst of energy for a dynamic economy. New entrepreneurial opportunities must be developed, or we will stagnate and lose competitiveness.

The entrepreneur is at the heart of structural change, and is a key factor in dynamic economic growth. Entrepreneurs—broadly defined to include risktakers in society whether they are associated with large or small organizations, public or private—by seeking out new investment opportunities, are the linchpin in the process of structural adjustments in a dynamic economy.

In a word, the American economy is becoming more Schumpeterian. In a Schumpeterian world, competition takes the form of new products and new processes and improved services. According to Schumpeter:

> The first thing to go is the traditional conception of the "modus operandi" of competition. Economists are at long last emerging from the stage in which price competition was all they saw. As soon as quality competition and sales effort are admitted into the sacred precincts of theory, the price variable is ousted from its dominant position. However, it is still competition within a rigid pattern of invariant conditions, methods of production and forms of industrial organization in particular, that practically monopolizes attention. But in capitalist reality as distinguished from its textbook picture, it is not that kind of competition which counts but the competition from the new commodity, the new technology, the new source of supply, the new type of organization (the largest-scale unit of control for instance)—competition which commands a decisive cost or quality advantage and which strikes not at the margins of the profits and the outputs of the existing firms but at their foundations and their very lives. This kind of competition is as much more effective than the other as a bombardment is in comparison with forcing a door, and so much more important that it becomes a matter of comparative indifference whether competition in the ordinary sense functions more or less promptly; the powerful lever that in the long run expands output and brings down prices is in any case made of other stuff.[1]

Well-defined equilibrium cost and demand curves are not relevant to economic decisions in dynamic competition. The environment is one of keeping pace with market trends and seeking to gain a market niche in areas of comparative advantage.

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[1] Joseph A. Schumpeter, "Capitalism, Socialism and Democracy," New York: Harper Colophon Books, 1942, pp. 84-85.

The essential feature of competition in a Schumpeterian world is that decisionmakers, public and private, are confronted with changing economic, business, and social relationships that interact on one another in a complex manner such that the outcomes in the process are difficult, if not impossible, to anticipate with a reasonable degree of certainty. The key to successful economic development within a changing economic environment is to manage the process of change to the advantage of the economy.

In dynamic competition, firms think strategically about their long-term position in world markets and less on the factors that influence current stock prices and public opinion. Generally, economies of large scale and technological innovation play an important role in long-term strategic business decisions.

Study Outline

This study is organized to provide a detailed analysis of the many factors that affect entrepreneurship and the process of technological innovation. Chapter II discusses the importance of stable markets and fiscal policies in creating an environment for entrepreneurship and innovation. The contribution of technological innovation to long-term economic growth is stressed. Chapter III describes the role of universities in technological innovation. Strengthening the linkage between academe and industry is viewed as a preferred alternative to the creation of new federally funded "generic technology centers" for encouraging commercial innovation. Chapter IV examines the contribution of government laboratories to the innovation process. Incentives to encourage collaboration with industry and conflict of interest problems are discussed. Chapter V describes some successful State innovation strategies for promoting technological innovation. Chapter VI presents the voice of the entrepreneurial community—what makes the entrepreneur tick and what he needs from government to continue ticking as a force in innovation, productivity, and economic growth. The discussion on the voice of the entrepreneur is taken from the record of field hearings held by the Committee in late August in Silicon Valley, CA, and at Boston's Route 128. The study concludes with a summary and conclusions, including recommendations for Federal actions to make the environment for innovation more friendly.

Study Recommendations

The major general recommendation, or even more to the point, the major plea, of this study is that we not fall into the trap of the industrial policy advocates, calling for targeting of specific industries or firms for promotion or renewal. Rather, we should target the "process of innovation." Congress should not get involved in choosing between which industries are worthy of government assistance and which are not. Instead, targeting the *process of innovation* will create an environment which fosters new ideas, new companies, modernization of mature companies, and will achieve the objectives of economic growth and expanding job opportunities.

In this process, the entrepreneur plays a key role. It is the entrepreneur who serves as the catalyst and facilitator in technological advancement which, in turn, is the key to productivity and economic growth. But the entrepreneur cannot operate in a vacuum. He needs the proper environment and the proper assistance from the Government—not government meddling, but government provision of a sound environment for technological innovation.

A major assumption of the study is that a national entrepreneurial policy ought to be broadly defined to include capital formation, technological innovation, trade policies, labor market adjustments, and fiscal and monetary policies. In addition, it should include specific policies typically associated with entrepreneurial economics such as the capital gains tax differential, incentive stock options, Securities and Exchange Commission regulations, and other policies that affect technology transfer, risktaking, and business enterprise development. The essential point is that a strategy to improve the Nation's climate for entrepreneurship and innovation, if it is to benefit a broad range of economic activities, must encompass a wide range of policies that affect the various components of the Nation's total process of innovation.

Because entrepreneurial activities tend to flourish in an expanding economy, macroeconomic policy, particularly the orderly expansion of aggregate demand, is important to the entrepreneurial process. Economic expansion, in turn, is determined by a number of interrelated supply-side factors including capital formation, saving, technological innovation, and human resource development, all of which should be part of our entrepreneurial policy. In short, the full range of government tax, expenditure, and regulatory authority must be considered in a strategy aimed at "targeting the process of innovation."

Structural shifts in the economy, due to changes in consumer preferences, foreign competition, resource prices, and technological change are another major source of growth-oriented entrepreneurial opportunities. The expansion of new industries and improvements in the products and process technologies of existing industries are major sources of entrepreneurial activities in a dynamic economy. But old and declining industries also offer new entrepreneurial opportunities through reorganization, new technologies, and better management.

A major source of structural change—although not the dominant force—is international competition. Changing world trade patterns have resulted in a shifting U.S. comparative advantage to a greater reliance on exports of capital goods, agricultural products, military goods, chemicals, and other high-tech oriented products. At the same time, the high value of the dollar is affecting the adjustment of the American economy to world markets, causing larger trade deficits. For this reason, the discussion of a national entrepreneurial policy would be incomplete without addressing the issue of U.S. exchange rates, interest rates, and government deficits.

A wellspring of new entrepreneurial activities, particularly those that are oriented to expanding the technological frontiers of the American economy, is technical change. Because technical change interacts with so many other factors, such as capital formation, its precise contribution to national economic growth is impossible to quantify. An important assumption of this study is that technological change is a dominant force in U.S. competitiveness and economic growth, but technical change generally does not occur in isolation from changes in the other economic growth determinants. In any case, technological change is important to the entrepreneurial process because it is the source of new ideas upon which entrepreneurial companies, old and new, depend.

Research and development is a vital input into the process of technological change in the American economy. Basic research is a process whereby original research germinates new concepts, or scientific knowledge. Research and development adds form and content to the new scientific concepts, which, when developed end up as new product and process innovations in the marketplace. For this reason, entrepreneurship and innovation are mutually reinforcing processes that result in new company formation, or technical change within existing industries.

As discussed, entrepreneurs are the agents of economic change in a dynamic economy. As capital formation, technological change, and growth in labor expand the economic horizons of the Nation, the optimum mix of investments will change, due to changes in preferences and dynamic comparative advantage. Economic growth and structural change are different dimensions of the growth process in a dynamic economy. Thus, a national economic policy that attempts to accelerate national economic growth, within the constraints of the preferences of the American public for current consumption relative to future consumption, is one that will emphasize capital formation, technical change, and the free mobility of resources among competing users.

The role of government in economic growth, as advocated in this study, is not the simplistic view that government has no role. The question is one of the appropriate role of government in the economic process.

While the policies advocated in this study do not pit high tech against traditional industries, or service industries against manufacturing, the study's recommendations offer the Nation hope for preserving a broad and strong industrial base. A strategy to encourage entrepreneurship and innovation, by stressing capital formation and technological change, will have its largest impact on R&D intensive industries. The fact that 95 percent of the Nation's commercial R&D is done within the manufacturing sector, which is also capital intensive, suggests that an entrepreneurial policy, as defined in this study, will benefit the "smokestack" industries as well as the high-tech firms.

Nonmanufacturing industries will also benefit from a higher rate of economic growth and technological change, since nonmanufacturing industries are major consumers of high-technology products and they benefit from larger national markets. Where would the banking and insurance industries be today without advances in computers, lasers, and fiber optic technologies. The fact is that all industries will gain from an improved national climate for entrepreneurship and innovation, provided the Government pursues policies to target the process of innovation and leaves it to the market to allocate the expanded pool of resources among competing industries.

II. U.S. ECONOMIC CHANGE, ECONOMIC GROWTH, AND INNOVATION

The goal of this chapter is to trace the trends of U.S. economic growth and productivity, and to debunk the theory that the United States is deindustrializing. It discusses factors that affect productivity and economic growth, and specifically, the factors that affect technological innovation. A summary and recommendations to stimulate long-term economic growth conclude the chapter.

LONGRUN U.S. ECONOMIC PERFORMANCE

Over the two decades, 1960–80, the U.S. economy did not perform well. At best, economic growth can be called "labored" and productivity growth was disappointing. Unemployment and inflation were on a stagflation roller coaster, rising to higher and higher peaks and troughs, both reaching peaks in 1980. Americans were becoming more and more disgruntled with the state of economic affairs and the 1980 election brought a new administration to the White House and the first Republican Senate in 26 years. Americans wanted a new policy direction. They were simply fed up with our economic malaise.

Tables I and II show the trends in the broad economic aggregates. Table I shows productivity growth rates (gross domestic product per employed person) for the United States and six other countries over the two decades, 1961–80, and over the last 3 years. It is a discouraging picture, at least up to 1980. We were outperformed across the board.

TABLE I.—PRODUCTIVITY (GROSS DOMESTIC PRODUCT PER EMPLOYED PERSON) ANNUAL RATES OF CHANGE, 1961–83

Country	1961–65	1966–70	1971–75	1976–80	1981	1982	1983
United States	3.1	1.1	1.0	0.7	1.4	–1.2	2.5
Canada	2.9	2.1	1.7	.4	.1	–1.4	1.9
France	5.4	4.5	3.6	2.9	1.1	1.9	1.0
Germany	4.4	4.3	2.8	3.1	.4	.6	3.4
Italy	6.1	6.4	2.1	2.8	0	–.4	–1.2
Japan	8.6	9.4	4.1	3.9	3.4	2.0	1.4
United Kingdom	2.4	2.8	1.8	1.6	1.9	3.8	3.2
Average, excluding United States	5.0	4.9	2.7	2.5	1.2	1.1	1.6

Source: U.S. Bureau of Labor Statistics.

TABLE II.—GROWTH RATES IN REAL GROSS NATIONAL PRODUCT, 1960–84

Country	1961–65	1966–70	1971–75	1976–80	1981	1982	1983	1984 (estimate)
United States	4.7	3.2	2.6	3.7	2.5	−2.1	3.7	6.5
Canada	5.7	4.8	5.0	3.1	3.8	−5.0	3.8	5.0
Japan	10.0	11.2	4.6	5.0	3.2	2.5	2.0	3.9
France	5.8	5.4	4.0	3.3	.2	1.5	.5	.6
West Germany	5.0	4.2	2.2	3.5	.2	−1.2	1.2	2.6
Italy	5.2	6.2	2.4	3.8	−.1	−.3	−1.5	1.9
United Kingdom	3.1	2.5	2.1	1.6	−2.0	.5	2.5	2.6
Average, excluding United States	5.8	5.7	3.4	3.4	.9	−.3	1.4	2.8

Source: Department of Commerce, IMF, OECD, and CEA.

Looking at total output, measured by real GNP, Table II shows that from 1961 through the mid-1970's, the United States trailed its industrial competitors, although the gaps are not as wide as in the case of productivity. The relatively better performance of GNP is due to a huge postwar "baby boom" in the United States, when strong labor force growth bolstered total output and helped to offset some of the decline in productivity per worker. But the general picture is the same. The United States was growing at a slower pace than the other nations.

IS THE UNITED STATES LOSING ITS COMPETITIVENESS OR DEINDUSTRIALIZING?

This brings up a question. Does the slow U.S. productivity growth and slow economic growth of the 1960's and 1970's mean that the United States is losing its competitiveness in the world? Contrary to the opinion of industrial policy advocates, the answer is no.

The United States trails other nations in real GNP and productivity growth, but the fact that other nations lead in the economic aggregates is no sign the United States is not competitive in the world.

How should competitiveness be defined? Analysts have a variety of definitions. The one adopted in this study is, "the ability to expand markets abroad while increasing the real income of citizens at home." An important consideration in the competitiveness issue so defined is that the market expansion should not be done through currency changes.

Real GNP and productivity growth are not necessarily measures of world competitiveness. True, productivity is an important factor underlying a nation's longrun competitive performance. But the key point is whether an economy is expanding in keeping with its longrun growth *potential*. If it is performing below its potential, it is losing its competitiveness. If it is growing in lockstep with its potential, it is maintaining its competitiveness. If we had high investment but low growth, we definitely would have a competitiveness problem, but that is not the situation in the United States.

The longrun potential for growth depends on capital formation, based on saving and investment decisions. U.S. capital formation is slower than that of other nations, and therefore, its potential for long-term economic growth is lower. This is *not* a sign of reduced competitiveness. U.S. industries are competitive within the constraints of relatively low capital formation. The central issue is whether the rate of capital formation is consistent with the preferences of the American public for long-term economic growth.

It is important to keep in mind that other industrialized nations have experienced recent slowdowns in output and productivity growth as well. In fact, GNP and productive growth suffered larger declines abroad. Thus, the relative position of the United States actually improved over the past 10 years.

In a related question, is the United States deindustrializing? Again, the answer is no. There are structural shifts taking place, and the relative position of manufacturing in the United States is declining, but U.S. manufacturing is still expanding overall.[1]

Regarding manufacturing output and employment, the United States fares quite well. Value added in manufacturing output has held relatively steady at about 24 percent of GNP since 1950, and the perception that millions of American manufacturing workers are being displaced by foreign competitors is simply untrue. Manufacturing jobs have increased every decade since the 1950's. When compared with the secular decline in manufacturing jobs in many European countries, the U.S. experience in manufacturing is quite impressive.[2] All industrial countries lost manufacturing jobs in the 1981–82 recession, but since the recession ended in November 1982, the United States has had the most dramatic job recovery of all nations.

Moreover, as a percent of world manufacturing exports, the United States is holding its own. Chart I, below, shows the world share of manufacturing exports in 1972 and 1982. The U.S. share has risen slightly from 12.1 percent in 1972 to 12.3 percent in 1982. Japan has risen sharply in its share of the world total, but this has been at the expense of Europe, not the United States.

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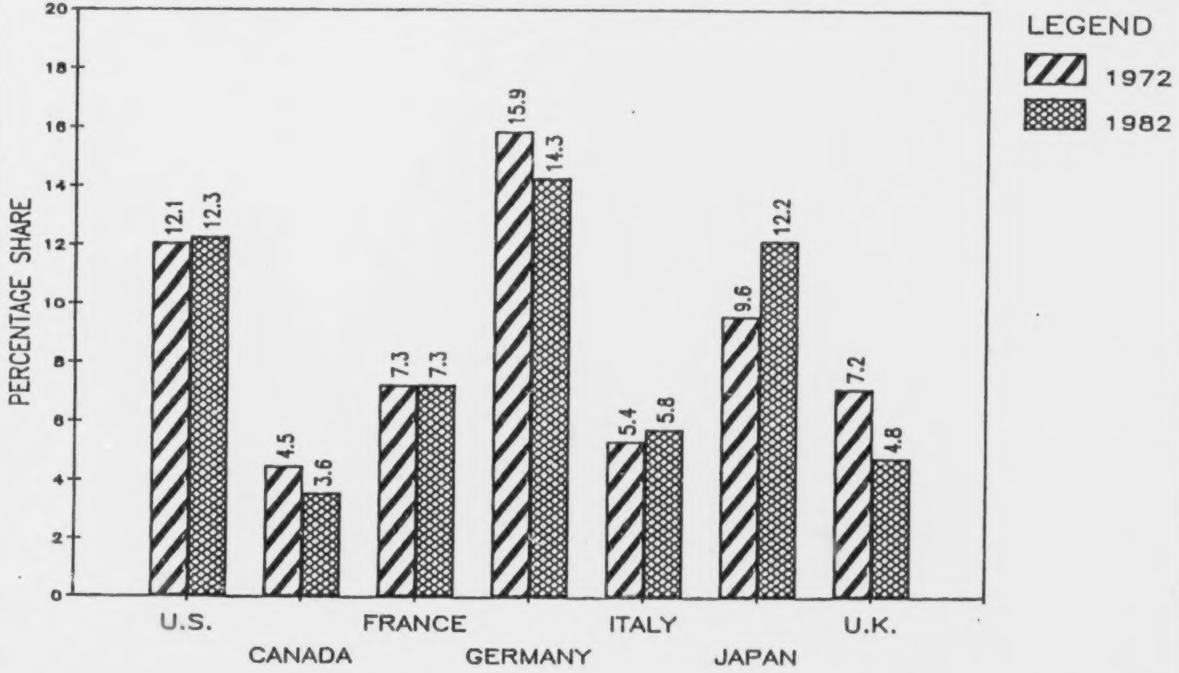
[1] This subject is treated in some detail in: U.S. Congress, Joint Economic Committee, "Industrial Policy Movement in the United States: Is It the Answer?" Joint Committee Print, Senate Report No. 98–196, 98th Congress, 2d Sess., June 8, 1984, Chapter IV, pp. 25–39.

[2] *Ibid.*

CHART 1

WORLD SHARE OF MANUFACTURING EXPORTS
SEVEN LEADING INDUSTRIAL NATIONS
1972—1982



SOURCE: NEW YORK STOCK EXCHANGE

What is happening in the American economy is that long-term structural changes are being reflected in rising fortunes for some industries and declining fortunes for others. Manufacturing *output* has kept pace with the national economy, and the world economy, but manufacturing *jobs* have been declining as a *percent* of *total* employment in the United States. These structural shifts reflect higher productivity growth in some sectors and shifts in consumer preferences. They do not reflect a loss of U.S. competitiveness in international markets. Foreign competition is important, but it is not a major causal factor in the long-term transformation of the American economy.

While service jobs have increased much faster than manufacturing jobs, manufacturing remains a dynamic source of employment opportunity for American workers.

Within manufacturing itself, some industries have been expanding and others have been contracting. From Table III below, it is clear that U.S. manufacturing is becoming more technologically sophisticated and skill intensive. The high-tech sectors increased their share of total manufacturing value added from 27 percent in 1960 to 38 percent in 1980. The heavy goods industries have declined in their relative contribution to value added in manufacturing.

TABLE III—SHARES IN U.S. MANUFACTURING VALUE-ADDED AND EMPLOYMENT

	Value-Added [1]					Employment [2]		
	1960	1970	1972	1973	1980	1972	1973	1980
Process:								
High technology	0.27	0.31	0.31	0.32	0.38	0.28	0.29	0.33
Capital intensive	.32	.30	.31	.32	.27	.30	.30	.28
Labor intensive	.13	.13	.14	.13	.12	.21	.21	.19
Resource intensive	.28	.25	.24	.23	.23	.21	.20	.20
End use:								
Consumer nondurables	.20	.17	.17	.15	.15	.19	.19	.17
Consumer durables	.03	.04	.04	.04	.05	.05	.05	.05
Automobile	.07	.06	.07	.08	05	.05	.05	.04
Equipment	.19	.22	.21	.21	.24	.20	.20	.23
Intermediate products	.51	.51	.51	.51	.50	.51	.51	.52

[1] Value-added computed the 85-industry level 1-0 divisions by multiplying gross output in constant dollars by the ratio of value-added in output in the 1972 1-0 table.

[2] Employment numbers derived from the Bureau of Labor series on employment and earnings aggregated im the 2-digit 1-0 divisions and then to the process and end-use categories.

The high-tech sectors have also increased their significance as a source of jobs in manufacturing. The high-tech sectors increased their relative contribution in manufacturing jobs from 28 percent in 1972 to 33 percent in 1980. In general, the high-tech sectors are identified as being those most dependent on R&D inputs and highly skilled labor (scientists, engineers, and technicians).

From a national perspective, industry transformations add up to a more efficient industrial structure for the United States. Fortunately, the American economy is blessed with a high degree of capital and labor mobility that allows its industrial structure to evolve into an efficient pattern—as dictated by competitive markets—without causing severe structural-adjustment problems.

The conclusions in all of this are that: (1) the U.S. economy is very dynamic, with the fastest economic growth of any industrial country at the present time, although admittedly we did not perform well in the 1960's and 1970's; (2) the United States *is* competing in world markets; (3) America is not deindustrializing; and (4) the United States is not suffering from massive long-term structural unemployment. There is unemployment, yes, and it is serious in some areas, yes, but it is not massive, and it is not getting worse. Our record on this is better than that of our European competitors. The long-term unemployment rate in the United States is much lower than it is in the industrialized nations of Europe.

While we do not have a competitiveness problem, we do have an economic growth problem. It is in the best interests of the United States to improve on the growth performance of the past several decades, not just to be a greater power in the world economy, but to increase real incomes and living standards at home. Strong and persistent economic growth is our greatest need.

What gives rise to economic growth? Two fundamental components:

1. *Growth in man-hours worked.*—The dominant component in manhours worked, of course, is the size of the labor force. The other determinants of man-hours are the employment rate, the average length of the workweek, and the number of weeks worked per year.

2. *Growth in productivity.*—A measure of labor productivity is output per worker per hour worked. Total man-hours worked and labor productivity give rise to the total output of a nation over a year's time (i.e., gross national product).

Labor Force and Man-hours Worked

Government policy cannot do a great deal to affect the size of the labor force which, in turn, is the major determinant in man-hours worked. The longrun growth in the labor force depends on such basics as birth rate, death rate, and the net immigration rate. Nor can government do a great deal to affect the labor participation rate. One of the most dramatic changes over the past three decades has been the substantial rise in the number of women in the work force.

In 1954, only 34 percent of females 20 years and older were in the work force. Today, that ratio is 54 percent, and rising. Who knows how high it will go. Interestingly, the male participation rate has *declined*, from 88 percent in 1954 to 77 percent today.

The U.S. labor force grew quite rapidly in the 1970's due to the post-World War II "baby boom." This has now ended, and over the next decade, labor force growth should settle back to its postwar average of about 1.8 percent per year, or more likely, 1.5 or 1.6 percent. Supporting these lower estimates, the Census Bureau's "moderate" estimate is for population to grow 0.8 percent over the next two decades, down from the 1 percent where it has been stuck since the baby boom ended in the late 1960's. Allowing for gradually rising labor participation rates, 1.5 to 1.8 percent is the maximum labor force growth we can expect over the next decade or two. That means growth in man-hours worked of about 1 percent, maybe 1.2 percent.

PRODUCTIVITY

Thus, productivity will have to bear the major burden of economic growth in the United States over the next decade or two.

What affects productivity? These are some basics that most analysts would agree on:

1. Economic growth and stability. (There is a "chicken and egg" synergism here. Productivity is basic to economic growth, but the pace and stability of economic growth also affects productivity.)
2. Increased and improved capital equipment available to each worker.
3. Technological innovation, primarily through research and development.
4. Reduced government regulation.
5. Improved labor quality and increased education and skill of the work force.
6. Improved entrepreneurial and management skills.
7. Labor-management cooperation.
8. Improved product quality.
9. Labor and capital mobility.
10. Access to good land and natural resources.

There are others and there are many subfactors under many of these, but these are all basic to productivity growth.

As discussed earlier, and as shown in Tables I and II, U.S. productivity and economic growth performance were not very good in the 1960's and 1970's. Why was this so? There are many reasons, some due to private sector failings and some due to public policy errors. It is primarily the latter with which this study is concerned, although some private sector faults will also be discussed.

First, U.S. economic policy in general has been at fault for the "stagflation" economy of the 1960's and 1970's. Unemployment and inflation were on a roller coaster, rising to higher peaks and troughs, seriously affecting longrun productivity and economic growth performance. While Keynesianism may have served us well in the 1930's and 1940's, and perhaps in the 1950's, it did not serve us well in the 1960's and 1970's. Policy actions were alternatively put on "stop" or "go" in an attempt to fine tune the economy and the economy responded in kind like a stagflation roller coaster from the mid-1960's until 1980. The distortions and economic malaise of this stagflation period had very negative effect on longrun productivity and real GNP growth.

Second, the United States is very much a consumption-oriented society, far more prone to consume than to save resources. It takes sacrifices to invest in economic growth, and this is a fundamental deficiency in the U.S. economy. Table IV shows that the United States has systematically invested a relatively smaller proportion of its resources into growth-producing capital formation than have other industrial nations. Our investment as a proportion of gross domestic product has been consistently smaller than our industrial competitors, particularly Japan. As a consequence, the United

States has experienced slower productivity growth and GNP growth and, thus a decline in the U.S. share of total world output.

TABLE IV.—GROSS FIXED CAPITAL FORMATION AND SAVINGS AS A PERCENTAGE OF GROSS DOMESTIC PRODUCT FOR SELECTED YEARS

	1962	1970	1978	1982
Gross investment as a percentage of gross domestic product:				
United States	17.6	17.6	19.5	16.6
Canada	20.5	20.8	22.2	21.1
Japan	32.9	35.5	30.8	29.6
France	21.4	23.4	21.4	20.5
West Germany	25.7	25.5	20.8	20.5
Italy	23.7	21.4	18.7	19.0
United Kingdom	16.8	18.5	18.0	15.4
Average, excluding United States	23.5	24.2	22.0	21.0
Gross savings as a percent of gross domestic product:				
United States	18.9	18.1	20.3	15.9
Canada	20.8	21.2	20.1	19.0
Japan	34.8	40.2	32.3	31.6
France	24.6	26.2	22.6	18.5
West Germany	27.3	28.1	22.8	21.5
Italy	26.0	24.2	22.4	18.8
United Kingdom	16.9	21.5	19.4	16.9
Average, excluding United States	25.1	26.9	23.3	21.1

Source: OECD Economic Outlook.

Investment in up-to-date plant and equipment is crucial to productivity growth. Capital formation and labor productivity fit together like hand and glove. In the 1950's and 1960's, the U.S. capital-labor ratio grew about 1¼ percent a year, actually declining in 1980. The slow growth of the capital-labor ratio in the 1970's is at the root of these reduced rates of productivity during the decade.

SAVING

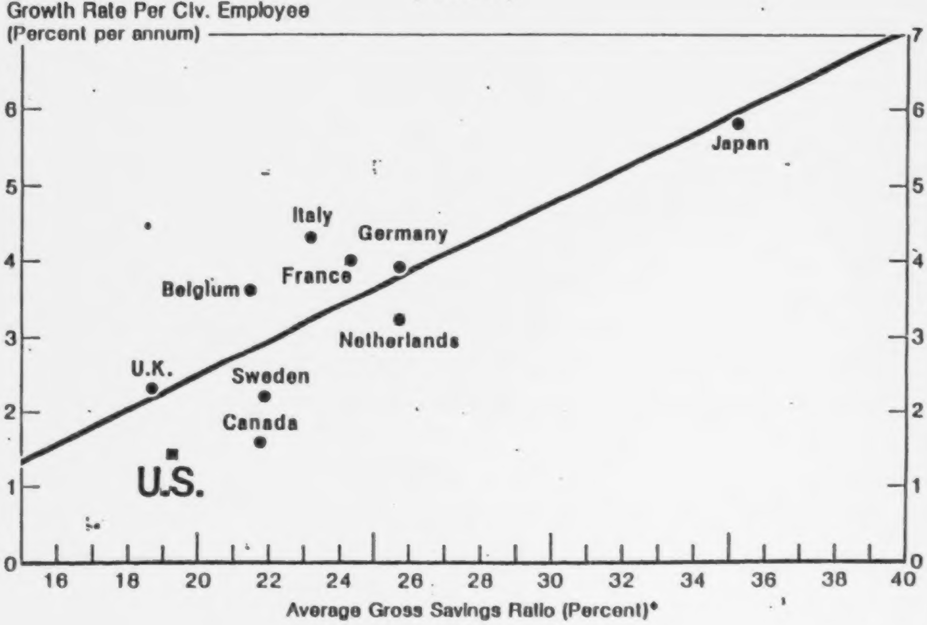
The financial capital for new investment spending comes from saving. Unfortunately, in our consumption-oriented society, the saving rate has declined. The average ratio of personal savings to personal disposable income in the United States fell from 7.3 percent in the 1970's to 5 percent in 1983. It has been running at about 6 percent in 1984, and appears to be on an uptrend. On the other hand, the Japanese save about 19 percent of their personal disposable income, and the West Germans save about 14 percent.

The trend in *gross* saving—including individuals, businesses, and government—is shown in the bottom tier of Table IV above and also in Chart 2 below. Clearly, the United States trails other industrial nations, in some cases, by a long way. A look at history and what our industrial competitor countries are doing should convince us once and for all that the countries that have the highest saving rates also have the highest investment rates and, accordingly, the highest productivity rates, the major factor in economic growth.

CHART 2

U.S. HAS HAD ONE OF THE LOWEST RATES OF SAVINGS AND PRODUCTIVITY GROWTH

(1960-80)



*Personal, business, and government savings.

SOURCE: U.S. TREASURY DEPARTMENT.

"Attitude" is not the only problem contributing to the U.S. high-consumption, low-saving pattern. Federal policies, particularly tax policies, have not been growth oriented. The U.S. low-saving mindset is *greatly influenced* by a Tax Code that imposes double taxation on savings—first on income, then on the income resulting from the investment of that income. In the corporate sector, earnings are taxed first as profits and later as dividends. Inflation compounds the problem by forcing individuals into higher tax brackets and by inflating corporate profits and distorting depreciation allowances. The net effect of the tax system is to lower the rate of return on saving and investment.[3] And it is not just the dollar impact on income and profits that hurt. Inflation also wrecks havoc with investment by introducing serious uncertainties into the investment process.

Third, government regulatory policies have also contributed to our low productivity growth by diverting resources from productive purposes to meeting environmental, product safety, and occupation health standards.

Government regulation, although desirable and beneficial in many cases, imposes heavy costs on society. The heavy costs and burdens on business (and ultimately on the consumer) have been almost ignored in setting regulatory policy. Regulation appears to have been pursued with "tunnel vision," looking only at the benefits, without concern for costs. It is time we took a hard look at the cost side of the equation; both the dollar costs and the time and burden costs. The Carter Administration started this process and the Reagan Administration has picked up the pace. This is not to say benefit consideration will be set aside, only that costs will be considered along with benefits.

We must improve cost-benefit analysis and monitor techniques of the regulatory agencies. Contradictory, duplicative, and unsuccessful regulations must be eliminated. This is the course that will help to increase productivity and foster economic growth, and still achieve the desirable aims of regulation.

IMPROVEMENTS IN THE PRODUCTIVITY ENVIRONMENT

Fortunately, many of the factors that had a negative impact on productivity growth in the 1960's and 1970's have been reversed.[4] With regard to the first factor on the above list, except for high real interest rates, the U.S. macroeconomic scene is in good condition right now. Inflation is low; growth is high; employment is expanding and, while there has been some slowdown in growth recently to more sustainable levels, the solid noninflationary expansion of the last 2 years should continue for some time to come. This provides a sound base for further productivity gains. Most important, tax policy has been set on a growth course, instead of a drag course. There is more to be done on this. We could take some lessons from the Japanese.

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[3] For a detailed description of how inflation, interacting with the Tax Code, has discouraged long-term U.S. capital formation and economic growth, see U.S. Congress, Joint Economic Committee, "The 1981 Midyear Report: Productivity," Report of the Joint Economic Committee, Washington, D.C., Government Printing Office, 1981, pp. 1-25. Also see U.S. Congress, Joint Economic Committee, "Productivity and Inflation," study prepared for the Joint Economic Committee, Washington, D.C., Government Printing Office, 1980.

[4] See an opinion editorial on this point by Professor John W. Kendrick, Wall Street Journal, Aug. 29, 1984.

With certain limitations, the Japanese do not tax saving income. On the other hand, the United States generally double taxes saving—when income is earned initially and, again, on the earnings from investment of that income. The Japanese have several other tax provisions that directly encourage investment: (1) with limitations, there is no capital gains tax on individuals; (2) the tax rate on investment income is 35 percent, half the regular top 70 percent marginal rate; (3) Japan has an R&D tax credit; and (4) there is a 10 percent tax credit for individuals receiving corporate dividends, thus reducing some of the burden of double taxation. Of course, these measures, by raising the after tax rate of return on investment, provide an additional stimulus to saving, since the opportunity cost of current consumption rises.

On the whole, the United States has taken some enlightened steps in the last 4 years to improve the tax environment for productivity and growth, but more can be done and we trust will be done. It may be time for the United States to move to a flat-rate consumption tax. This tax system would have the ultimate beneficial effect on savings and investment.

The costs of complying with social regulations have begun to level out as a percentage of GNP after major increases in the 1970's. Moreover, some of the uncertainties, so destructive of incentives to invest, are being removed by regulatory reform. Economic deregulation is lowering prices in some portions of the transportation, communications, and financial sectors and has increased competitive incentives for higher productivity. The work on this, begun by President Carter, has been continued under President Reagan.

The post-World War II baby boomers who swelled the ranks of inexperienced youthful workers in the late 1960's and in the 1970's are now passing into their productive working years, with beneficial effects on productivity.

Finally, there have been favorable developments in labor-management relations in the past several years as a result of the impact of keen foreign competition and the recessions of 1980 and 1981–82. Not only have nominal wage-rate increases moderated significantly, but many new union contracts have reduced or eliminated restrictive work rules that hurt productivity. Both union and nonunion workers increasingly are participating in quality circles and other joint labor-management team efforts to improve productivity. There has been a substantial turnaround in productivity and economic growth in the United States since the recession ended in November 1982. We are optimistic that this can continue for many years to come—if we pursue intelligent policies.

Technological Innovation

A major determinant as to whether the U.S. economy will, indeed, enjoy a healthy longrun secular rise in productivity and economic growth hinges very much on item No. 3 in the above list of factors that affect productivity (i.e., technological innovation). This is the subject of the remainder of this chapter and the remainder of this study.

Technological advancement is probably the least understood of all the factors affecting productivity and growth. And yet, it is one of the most important contributors to growth. In fact, it is probably the chief long-term factor driving up productivity, based largely on research and development. Technological advancement is defined as technical and managerial knowledge that leads to new and improved production methods and processes, and to new products and services. It also includes more efficient utilization of resources as a result of improvements in organization, management techniques, transportation, and communications.

Quantity increases in capital stock (item 2 on the foregoing list) are a necessary but not a sufficient condition for good productivity growth. There must also be improvements in the *quality* of capital, via technological advancement (item 3 on the foregoing list). Innovation is also a necessary but not a sufficient condition for productivity growth. Increases in the quality of the capital stock alone are not enough. *Both* are necessary.

Much has been written about capital investment and its contribution to productivity.[5] There is considerably less literature on the role of innovation.

What produces technological innovation? The following are some of the basics:

1. Expanded research by government and research and development by the private sector is the most important factor.
2. Increased supply of scientists and engineers.
3. Good patent and antitrust laws.

Technological innovation is basically a private sector activity, but there are some things the Government can do. Some policies are highlighted here.

The most important factor in technological innovation is an aggressive research and development program by both the private and public sectors.

The United States has been the world's technological leader throughout the postwar period. U.S.-based scientists have won a major share of Nobel prizes. Indeed, the U.S. economy originates a large proportion of all new products. Only Japan is a serious challenger to our technological leadership.

Yet, as our trade deficit with Japan in high technology increases, serious questions are being raised about our ability to retain our technological position. For example, 10 years ago America's leadership position in microelectronics was unchallenged. Now in several critical areas, the Japanese are verging on leadership. Unless current trends are reversed, the advantages the United States now hold will erode further. It is essential that we assess and bolster the critical wellheads of technological advancement.

RESEARCH AND DEVELOPMENT

If investment in physical capital is the vehicle, research and development is the engine of technological progress and productivity. R&D improves the *quality* of capital of state-of-the-art advancements. A recent study by the National Bureau of Economic Research shows a positive connection between the rate of R&D expenditures and the rate of productivity increase in various industries.[6] Edwin Mansfield has shown that productivity growth in an industry or in a firm is directly and significantly related to the amount spent on R&D by that industry or company.[7] In another study, Richard T. Atkinson found that growing industries—those generating new jobs and rising income—have relatively high rates of investment in R&D.[8]

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[5] See bibliography at the end of this study.

There are important "spillover" effects from R&D because one industry's R&D frequently results in important inputs in other industries. In a study of 17 innovations in various industries, Mansfield found that the median *social* rate of return on investment is more than double the median rate of the return to the company itself, before taxes.[9]

The United States and West Germany have the highest ratios of research and development to gross national product of any industrial country. From the late 1960's to the 1970's, the share of R&D expenditures to GNP in the United States fell from about 2.9 percent in 1967 to about 2.2 percent in 1978. It has risen since then to 2.7 percent in 1984. The U.S. ratio exceeded Germany from the late 1960's to the mid-1970's, but has followed behind since then. Overall, though, the U.S. spending on R&D relative to GNP has grown as rapidly as any other industrial country since the late 1970's.[10] (See Chart 3.)

When military research is stripped out, the United States falls down into the pack. Chart 4 shows civilian research and development expenditures as a percent of GNP in four major countries. In 1967, the United States led the other industrial countries but has since trailed Germany and Japan by wide margins, although the U.S. ratio has been on an uptrend since 1978.

In 1981, the latest year for which data are available for all industrial countries, civilian R&D expenditures in Germany were 2.6 percent of GNP. In Japan, the ratio was 2.3 percent. In the United States, it was 1.7 percent. While there is a great deal of spillover benefit to the civilian sector from military R&D expenditures, it is still clear that the United States needs to commit a larger share of GNP to civilian research and development if we hope to maintain our technological lead in the world.

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[6] National Bureau of Economic Research, "R&D, Patents and Productivity," University of Chicago Press, Chicago, IL, 1984.

[7] Edwin Mansfield, Seminar on Research Productivity and the National Economy, House Committee on Science and Technology, June 18, 1980, p. 6. Also: "How Economists See R&D," Harvard Business Review, November-December 1981, p. 98.

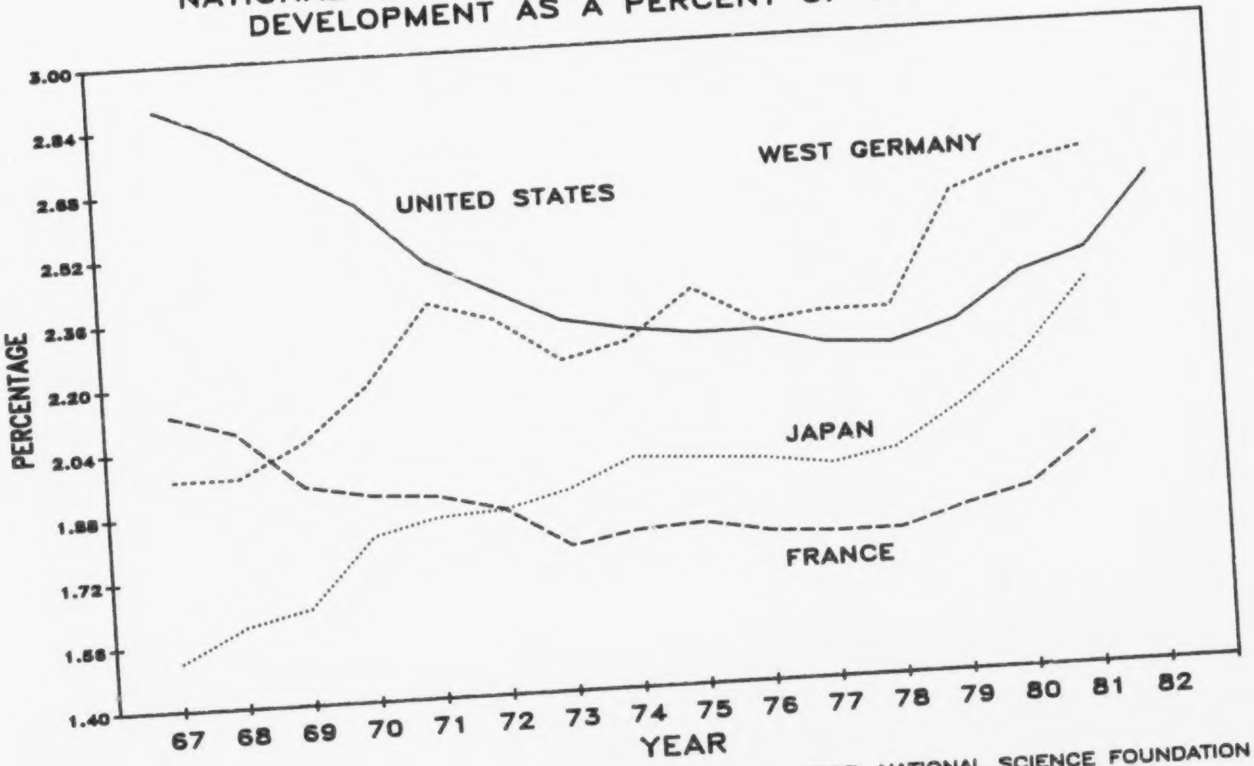
[8] Richard C. Atkinson, "The Role of Research and Development in Economic Progress," National Science and Technology Policy Issues, House Committee on Science and Technology, 1979, p. 24.

[9] Edwin Mansfield, "Economic Growth and Stagnation: The Role of Technology," National Planning Association, "Looking Ahead and Project Highlights," spring, 1980, p. 5.

[10] Note: Data on R&D in the United Kingdom are very sketchy, generally unavailable, and are not shown on Charts 3, 4, and 5.

CHART 3

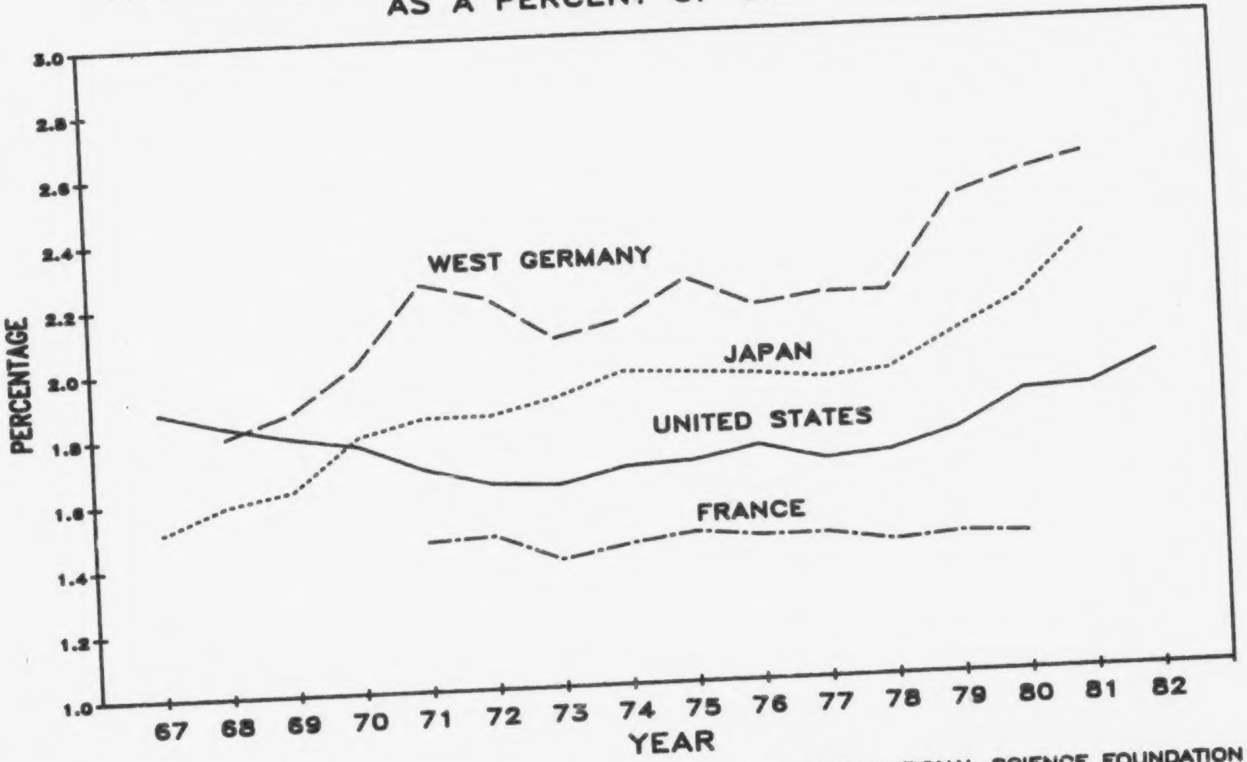
NATIONAL EXPENDITURES FOR RESEARCH AND DEVELOPMENT AS A PERCENT OF GNP



SOURCE: NATIONAL SCIENCE FOUNDATION

CHART 4

CIVILIAN RESEARCH AND DEVELOPMENT EXPENDITURES
AS A PERCENT OF GNP



SOURCE: NATIONAL SCIENCE FOUNDATION

In fiscal year 1984, the United States spent $97 billion on R&D; of this, $44 billion, or 46 percent, was funded by the Federal Government. This is an historic low figure for the Federal share of R&D spending. However, the Federal Government still plays a major role in basic research.

Basic research accounts for 12 percent of total research expenditures and applied research for 22 percent. Development activities comprise 66 percent of the national R&D outlay. The Federal Government funds two-third of the Nations basic research, and rightfully so. This is the type of research where the benefits are unclear, and privately funded researchers often cannot undertake the risk. Yet, it is the area where knowledge and understanding of the fundamental aspects of the universe are gained, and such research serves as the foundation of many innovative products and processes.

Fortunately, one previous thorn in the side of R&D was cleared up late in the 98th Congress. Some uncertain legal restraints on joint R&D ventures were corrected by Public Law 98-462, and joint ventures can now go forward without fear of bringing down the wrath of the Antitrust Division. This will avoid costly duplication in R&D.

More can and should be done to promote commercial R&D. For one thing, the 25 percent tax credit should be made permanent. It is scheduled to expire next December. We should also: (a) replace the rolling base restriction with a base using an average of 1983-84 R&D expenditures; and (b) permit tax deductions for contributions of equipment for teaching science. (Under present law, equipment can now be donated for research purposes.)

The increase we have had in R&D spending the past few years, even after allowance for lags, is contributing, and will contribute, to an increase in the flow of cost-reducing investments and innovations. We urge that the increases in R&D spending the past few years be extended, particularly by the Federal sector, but also by the private sector.

SUPPLY OF SCIENTISTS AND ENGINEERS

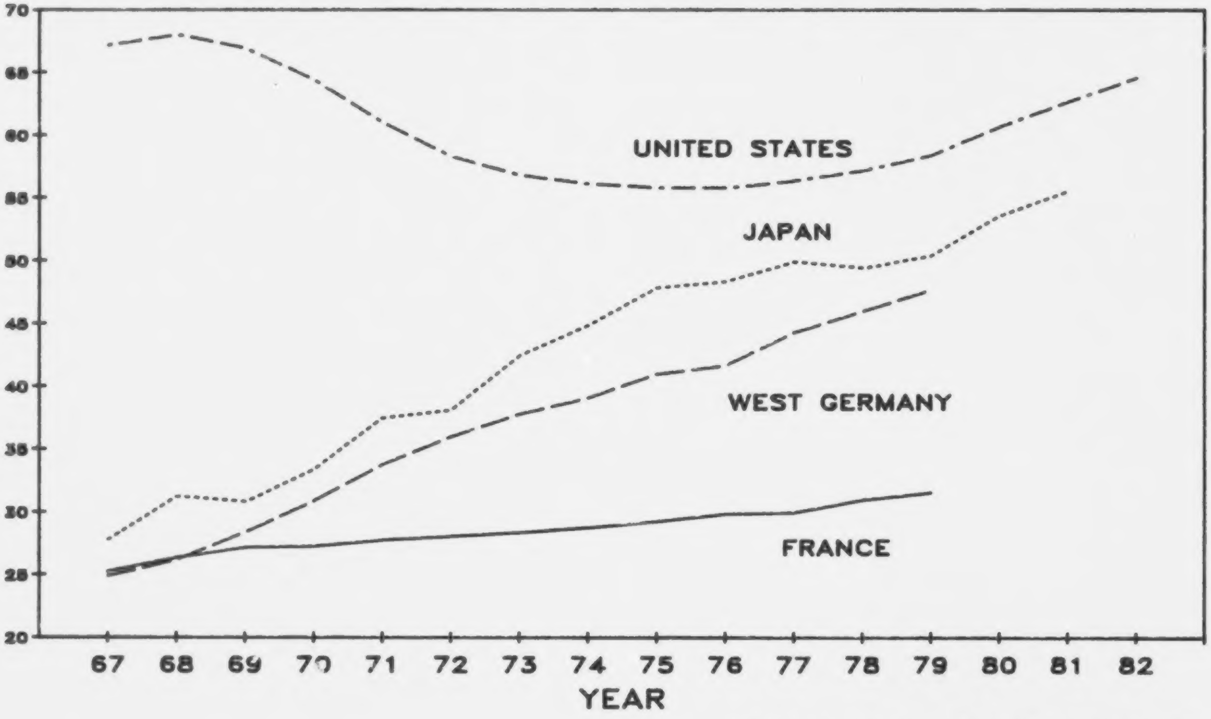
Money alone will not achieve research and development. It requires an expanding scientific and engineering manpower base. The number of R&D scientists and engineers in the United States rises year by year—from 530,000 in 1967 to an estimated 750,000 today. Both in total and relative to the total labor force, the United States has the highest proportion of scientists and engineers in the labor force of any country except the Soviet Union. However, from the late 1960's through the early 1970's, the ratio of R&D scientists and engineers to the labor force declined in the United States, from 67.2 per 10,000 in 1967 to 55.8 in 1976. The ratio has increased in the past few years, rising to 64.6 in 1982, but it has not yet regained its former level. In most other countries, especially Japan and West Germany, this ratio has steadily increased over the 1960's and 1970's. (See Chart 5.)

Moreover, some of the best U.S. scientific and engineering manpower has been diverted to the defense and space programs, at the expense of civilian programs. We will have to face up to the fact that national defense requirements will always absorb a major portion of U.S. scientific and technological manpower, and the recent expansion in weapons procurement has added and will continue to add additional demands on the Nation's scientific and technological resources.

But of major concern relative to the growth in the labor force is that the supply of scientists and engineers in the United States has fallen markedly behind the growth ratios of other advanced industrial nations. In 1980, the United States granted 69,300 bachelor degree-level engineers, while Japan graduated 73,500, with a population half that of the United States. The effect has been to drive up wages for engineering talent, thereby increasing the costs of R&D, and constraining its scope. The United States needs a re-ordering of educational priorities if we are to continue to be the world's technological leader.

CHART 5

SCIENTISTS AND ENGINEERS ENGAGED IN RESEARCH
AND DEVELOPEMENT PER 10,000 LABOR FORCE POPULATION



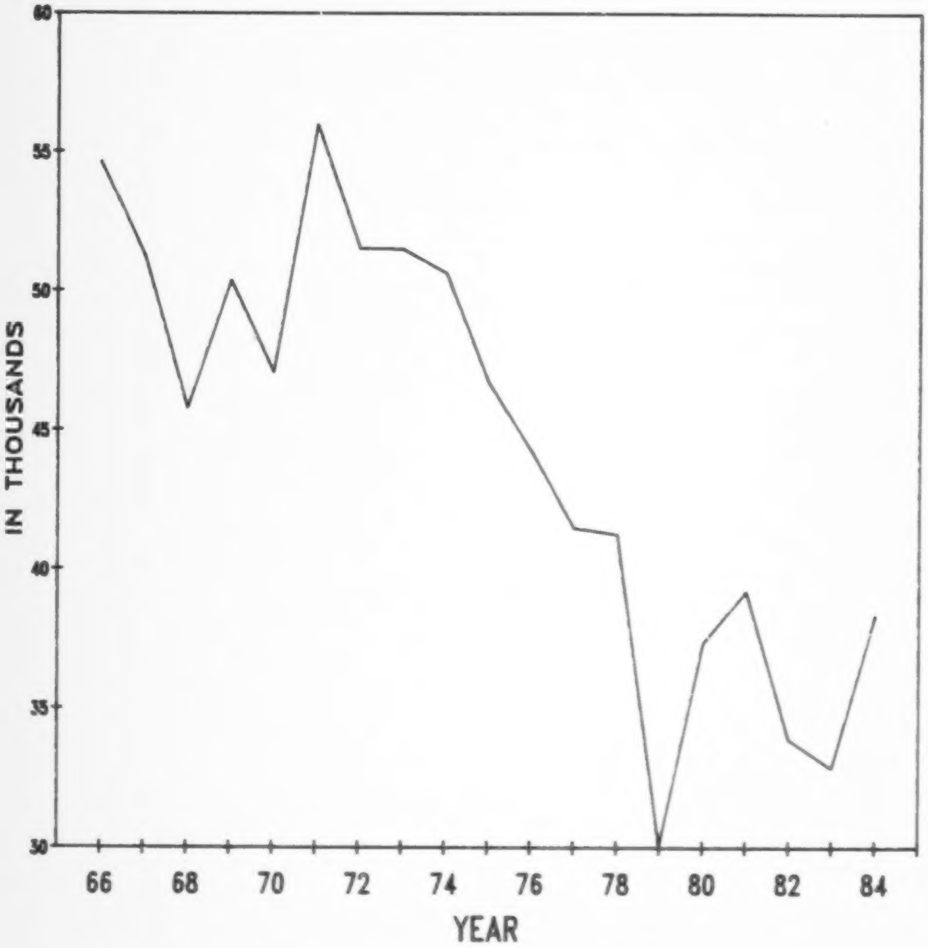
SOURCE: NATIONAL SCIENCE FOUNDATION

PATENTS AND ANTITRUST LAWS

Of course, manpower and dollar inputs into the R&D process can only proxy for what we are seeking—innovation. Innovation is difficult to measure, but a good indication of what is occurring is patent statistics. The trend on domestic patenting is clearly down. The decline between 1971 and 1984 is over 31 percent. This is shown in Chart 6. At the same time, patenting in the United States by Japan and Germany has been rising and, in 1982, over 40 percent of all U.S. patents granted went to foreigners, primarily to Japanese inventors.

CHART 6

U.S. PATENTS GRANTED TO U.S. INVENTORS
1966 - 1984



SOURCE: U.S. DEPARTMENT OF COMMERCE, U.S. PATENT AND TRADEMARK OFFICE

Some of the problem lies with the U.S. patent system itself. The patent system was created to promote innovation, but certain aspects of the system are barriers to innovation. One problem is that title to inventions made under Federal funding generally is vested in the Government (with the exception of those inventions made by small businesses, universities, or not-for-profit organizations). Only 5 percent of government-owned patents are ever utilized in the private sector, compared to 40 to 65 percent of private-owned patents.[11] The reason is that without title to an invention and 17 years exclusivity it provides, an individual or company will not invest the time and money necessary for the development of a marketable product.

There is some controversy on this. Some proponents argue that title should remain in the public sector where it is accessable to all interested parties. Permitting contractors to retain title would constitute a subsidy to large companies and would reduce competition. Large corporations, which have the ability to procure government contracts, would benefit the most. Nonetheless, responsibility for commercialization resides in the private sector and, then government retains title, industry is less likely to follow up with the additional steps necessary to produce an innovation.

Congress has taken one step to correct the problem. Public Law 96-517 provides for title to be vested in contractors if they are small businesses, universities, or nonprofit institutions, provided they commercialize within a brief, agreed-upon, timeframe. The law should be expanded to cover all contractors.

One other aspect of the patent process that needs attention is that the 17-year patent life should begin after the patent is finally approved by the Government. Under current procedures, patent approval is excruciatingly long, awaiting government testing and legal research. While a "patent pending" stamp may be some deterrent, it is no guarantee of protection.

Finally, in a related matter, antitrust and intellectual property laws should be amended to require the courts to consider the effect of competition when judging alleged patent misuse by a patent holder and alleged antitrust violations in the licensing of intellectual property. Often, the most efficient way to bring a new technology to market is by licensing that technology to others. Licensing can enable intellectual property owners to use the capabilities of established enterprises to market a technology quickly and at lower costs. This would be especially valuable in the case of small businesses that do not have the ability to develop all possible applications of new technologies by themselves.

On another matter, patent protection by U.S. process patent holders should be strengthened by enforcement of a U.S. patent against a product made in a foreign country by the U.S. patented process. Today, foreign companies can use U.S. process patents abroad without authorization, and turn around and sell the resulting products in the United States with impunity.

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[11] Wendy H. Schacht, "Industrial Innovation: The Debate Over Government Policy," Congressional Research Service, Library of Congress, published issued brief, Aug. 22, 1984.

III. UNIVERSITY-INDUSTRY COLLABORATION

The growing importance of basic research to American industries has strengthened backward linkages to the American university system. Universities and industry are developing a wide variety of collaborative mechanisms to benefit both parties. The result is a reemergence of the role of academe in the Nation's overall environment for entrepreneurship and innovation.

This chapter examines factors behind the growth in the university-industry collaborations, the benefits to both parties, and the pitfalls to be avoided in such relationships. The chapter concludes that university-industry collaborations, properly structured to protect the academic integrity of the American university system, offers an attractive means to speed the development and diffusion of commercial technologies.

The first section of this chapter examines the emerging role of academe in economic growth in the light of America's entrepreneurial revolution, and the profound changes that have affected university-industry linkages in recent years. The second section looks at the economic potential that exists in stronger university-industry collaborations, with special attention to the implications of such collaboration for entrepreneurship and innovation. The danger of carrying the collaboration to the extent that it violates the fundamental principles guiding the university is also discussed. The third section describes the practical difficulties that have arisen in setting up collaborative efforts, and the efforts made to overcome them. These difficulties stem from industrial and government policies and attitudes as well as university ones. The answers, however, stem from both groups who have made efforts to understand the singular roles that universities and commercial firms play in our capitalist society. The chapter concludes with a discussion of how Federal policies can help maximize the benefits of university-industry collaboration.

THE EMERGING ROLE OF ACADEME

For centuries, universities have provided the world with knowledge and educated manpower, while pursuing the fundamental principles of intellectual freedom and scholarly communication. Although they have not shied away from controversy, the more durable of them have maintained their essential qualities through vast and sometimes sudden changes in the political and economic structures of the nations where they have been situated. Today, as they were centuries ago, universities are still the world's primary source of basic knowledge and free inquiry.

They are also one of the most stable institutions of mankind. Of the 66 institutions today that have kept their original form from the early 16th century, 62 of them are universities. This stability evidently stems from the value society places on institutions that steadfastly follow these principles of inquiry and communication. But it is also the result of a deliberate pragmatism. As a witness before the Joint Economic Committee pointed out, "Our universities *do* change in response to societal influences, while seeking to preserve their fundamental characteristics." [1]

Universities in the United States are again under challenge to change, in ways that possibly threaten their independence. This challenge comes from a familiar combination of economic and political pressures, including pressures from government.

The present setting, however, is unique. It is influenced by two characteristics of our technological age that have altered, perhaps permanently, the interaction between university and commercial research.

(1) There is a growing dependence of the Nation's economic and business system on technological information which, in its basic form is usually found at university; and

(2) In several areas there has been a substantial increase in the speed at which basic research findings are being translated into technology with commercial potential. In this "postindustrial" era, *information* is the key to economic competitiveness as much as material strength and ingenuity were previously. As the source of basic information, the university is now looked to by many technology-intensive firms as possibly providing the answers to matters of prime business importance. As one high-tech executive described it recently:

> Inventions of ultimate technological and economic significance once could be made by intelligent, persistent thinkers with little formal higher education. Edison, the Wright brothers, and Henry Ford come to mind. Modern technological advance, however, is a different story. Consider the transistor, the laser, or synthetic insulin. . . . You don't find these associated with tinkering in a basement or garage. . . . Thus, the modern R&D enterprise is inextricably linked with the research university. . . .[2]

Government is concerned with these "inventions of ultimate technological and economic significance," both as a consumer of high technology and as a prime mover of economic growth. The hand of government in promoting a closer linkage between industry and universities can thus be seen at all levels, Federal, State, and local. Bills to establish generic technology centers at universities, to subsidize research parks associated with universities, and to subsidize university research in specified technologies have been introduced in the 98th Congress. State governments, through their state university systems, are active in promoting their economics as centers of technological development. Many local governments have helped establish business development and "incubator" facilities, often combining with local universities to do so.

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[1] Donald N. Langenberg, testimony published in U.S. Congress, Joint Economic Committee hearings on "Climate for Entrepreneurship and Innovation in the United States," parts 1, 2, and 3, 2d sess., 98th Cong., p. 13.

[2] Ibid., p. 8.

The swiftness of the pace of technology development is also a matter of government concern. Speaking of the revolution in science that has been taking place around us, one observer noted that "the relatively long time lag [between basic research findings and commercial development] has practically vanished in many fields of scientific and industrial activities."[3] This has resulted in a broader overlap between the basic research being carried out at universities and in industrial firms. In more and more fields—for example, surface analysis, molecular beam epitaxy, and laser-assisted DNA analysis—the academic researcher is dealing with the same scientific and engineering problems as the industrial one.

Thus, the industry-university connection is germane to a report on the Nation's climate for entrepreneurship and innovation. The modern, high-tech entrepreneur sometimes comes from a university staff. More often, as this chapter points out below, he or she benefits from some university affiliation. In many cases, the entrepreneur has developed technology that is purchased by larger firms, who themselves carry on an extensive university-collaborative network. In any event, each party relies on—and is often involved in developing—the basic knowledge and research that is generally found in a university setting.

THE POTENTIAL OF UNIVERSITY-INDUSTRY COLLABORATION

Gatorade, stannous flouride as a toothpaste ingredient, irridated milk, lasers, anticoagulants, synthetic fibers, semiconductors, and atomic power: These products owe their existence in whole or in part to university research. If the list were extended to include all inventions in use today that derived from such research, it would extend to hundreds of entries.

This albeit simplistic view of university activity—that it provides the basic, and some of the developmental, research undelying important commercial developments—has been accepted by policymakers and industrial leaders, and built into the legislation that established and still guides the university-industry-government system this country enjoys today. With the passage of the Morrill Act more than 100 years ago, Congress established a tripartite partnership that has helped produced some of the most technologically modern industries in the world. The land grant college system has set the standard, as it were, for many other institutions in their dealings with industry.

Today, the Federal Government provides approximately $5 billion for university research, or about two-thirds of university R&D funding. While industry contributes less than $½ billion for university R&D, it provides significant other funding for facilities, scholarships, etc. Industrial contributions to universities have continued to grow during the postwar era, and presently amount to more than $1.2 billion per year.

A number of important public policies have been encouraging and facilitating the trend to improved university-industry relations. The provisions of the Economic Recovery Act of 1981 provides tax incentives to encourage university-industry collaboration. The incremental R&D tax credit allows a 25 percent credit for 65 percent of the cost of contract research, including payments to universities and faculty. Also, deductions for equipment and donations to universities increases the attractiveness of industry collaboration with universities.

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[3] George E. Palade, in Thomas W. Langfitt, et al., eds. "Partners in the Research Enterprise: University-Corporate Relations in Science and Technology," Philadelphia: University of Pennsylvania Press. 1983.

Probably the most significant statutory incentive has been changes in patent laws, to allow universities, small businesses, and nonprofit organizations to have title to patents developed from federally funded research. The potential for fees from leasing and licensing development rights to university patents provides a powerful incentive for universities to seek out research ties with industry, and to compete more vigorously for Federal R&D funding as a mechanism for leveraging corporate R&D support. Many major universities now have patent offices and faculty consulting and research policies to facilitate collaboration. The development of research parks at or near major university facilities is also being used to lure industry.

Over the past few years, dozens of experiments have been mounted to make this connection more productive. The Federal Government has sponsored several industry-university joint programs in addition to its own research contracts with universities. Virtually every State now has a "high-tech" initiative as part of its economic development activities. Some industrial firms have made conspicuously large or innovative arrangements with universities to promote advances in technological fields such as chemical research or manufacturing technology. In the field of biotechnology, approximately 200 "startup" firms have been established recently, many of them by university researchers; this has happened, to a lesser degree, in other fields such as computer science. And many universities seem to be more open than previously about engaging in industry-oriented research and other assistance.

These developments have brought their problems for both parties, but especially for universities. In 1982, for example, a "summit" conference of university presidents sounded the warning that research arrangements with industry should—

> not promote a secrecy that will harm the progress of science; impair the educational experience of students and postdoctoral fellows; diminish the role of the university as a credible and impartial resource; interfere with the choice by faculty members of the scientific questions they pursue, or divert the energies of faculty members and the resources of the university from primary educational research missions.[4]

What kinds of conclusions can we draw from these activities about the future of American entrepreneurship? This study identifies six primary ones, each of which affects the response that the Federal Government might take in improving the Nation's environment for entrepreneurial activity.

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[4] Report of the Pajaro Dunes Conference (excerpt reprinted in Partners in the Research Enterprise), op. cit., p. 36.

Common Interest

First, there is a natural convergence of interest that has become more prominent recently between technology-based firms and universities.

From an industrial standpoint, a technological advantage is sometimes critically important for maintaining competitiveness. Universities, in this context, are an important base for industry's technological resources. Basic research has always been an important—usually indirect—input to developmental research, especially at the design stage. Today, however, in some fields it is difficult to distinguish the two from each other. At least one university president has observed that "the lines between basic knowledge and its application are becoming blurred in a number of fields; and that fundamental research often provides solutions to industry's problems."[5] Apparently, as the gap between basic and development research narrows—as it evidently has for many industries—closer university-industry ties become more beneficial to both parties.

Access to universities can accelerate this development process. Often the access to university basic research can best be gained through hiring someone who has worked on the relevant technology as a graduate student or professor. Therefore, an important additional benefit that industry derives from a close connection with universities is access to educated scientific and engineering manpower.

From the university standpoint, the interest in closer ties with industry is based both on the potential in closer ties and on the economics of education and research today. The potential in closer ties stems from the fact that research departments of large corporations are often better equipped than the average university laboratory and often perform basic research that would be valuable in a university setting. Also, the scholarly communication that characterizes university activity does not stop at the university gates: The interchange of ideas also takes place through symposia, professional societies, and research organizations such as the National Research Council, which bring university and industrial scientists and engineers together on a regular basis.

The economic basis for universities to seek closer industrial ties is practical as well. Faced with declining enrollments and rising costs, many universities have been forced to seek additional amounts of corporate funding. This has given impetus to special efforts on the part of universities to establish industry-oriented centers for research in industrial areas such as biotechnology or manufacturing (rather than traditional university scientific/engineering areas such as biology or mechanical engineering). And university scientists, a government-sponsored report notes, "are beginning to look to some industrial laboratories as a way to gain access to frontier equipment and technical advances." [6]

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[5] George M. Low, "The Organization of Industrial Relationships in Universities," Partners in the Research Enterprise, op. cit., p. 68.

[6] Lois Peters, Herbert Fusfeld, et al., "Current U.S. University-Industry Research Connections," University-Industry Research Relationships, National Science Board, 1982, p. 68.

The Public Interest

There is a distinct and somewhat different public interest in closer industry-university ties that includes government as well as university and industry partners. A strong, productive industrial sector today is, by definition, one that keeps up to date in the application of the most advanced technology. The rapid rate of development and application of new technology, therefore, has a direct bearing on this country's balance of payments, the inflation rate, and the productivity growth rate. Maintaining America's ability to innovate continually in the industrial sector will require maintaining a vigorous and well staffed/equipped university system, and an effective set of mechanisms for technology transfer. There is considerable evidence today that public policy officials are aware of the potential of industry ties to strengthen the Nation's university system.

Traditional University/Industry Roles Are Changing

A small shift in the traditional roles of industry and university are evidently taking place on some campuses and in many industrial firms. A number of university-based technology centers derive their success from the quasi-entrepreneurial activities of their directors and staffs; these centers actively seek industrial contracts, and willingly undertake some projects (e.g., product testing) that a conventional university science or engineering department might find unacceptable. On the other hand, some industrial firms perform basic and applied research with resources that are beyond the capability of most universities. Funded in part by large government contracts, firms have made profound advances in the state of the art in such fields as numerically controlled machine tools, composites forming, and computer-aided design. A few large firms have inhouse continuing education centers where many technological courses are taught that are not freely available at most universities (e.g., design for productibility, stress screening). In those fields where industry has made great strides, technology transfer, rather than from university to industry, is the other way around, from industry to university.

Research Setting Generates Entrepreneurial Ideas

The kinds of entrepreneurs that have capitalized on high-tech invention have typically depended for their ideas on a university or an industrial research department setting. In many cases, research underlying a new invention has been started at a university or industrial firm; the spinoff of a new firm has occurred when the parent university or industrial firm became an inappropriate place to pursue the research further. In any event, proximity to a university or group of universities, and to other high-tech firms, gives the high-tech entrepreneur the intellectual stimulus that would be unavailable to smaller companies operating alone.

Universities Assist Startup Firms

A related factor, some startup firms that are too small to support large research departments have found that they can avail themselves of university personnel and facilities—in effect, gaining the advantages of a larger research department at a lower cost. This advantage can be critical where expensive testing equipment is involved.

Universities Can Leverage Corporate Research Budgets

The array of Federal and State government programs to support high-technology development at universities enables each industry dollar to be substantially leveraged when used to pay for university research. Most government-sponsored, university-based research centers cover their overhead with taxpayer funds; thus, industrial "clients" pay only for materials and staff time. One such center that receives support from the State legislature and the National Science Foundation, as well as industry memberships, estimates that the leveraging factor for each industry dollar is approximately 200 to 1.

The above points indicate the potential for speeding the process of the commercial development of new technology that exists through industry-university partnerships. They also indicate the pitfalls being encountered, and the dangers in pushing industry-university collaboration too far. For the fact is that too close an identification of university interests with those of its industrial sponsors could compromise the principles upon which the university is based. This is not an idle issue. One of the Committee's witnesses, himself a university chancellor, warned that "our research universities are wrestling with many fundamental questions about the extent to which they should or can strengthen their interactions across the interface with industry and the private sector generally, without risking damage to the fundamental academic values which are the basis of the stability and durability to which I referred earlier." [7]

Indeed, the lure of economic growth through high-technology development has attracted significant governmental interest, Federal, State, and local. Most of this is based on the simple but effective notion that the "Silicon Valley" model has potential for other parts of the country. Thus, most State university systems are deeply involved in promoting industrial relations, through "incubator" facilities, engineering centers of excellence, specialized industrial research consortia, and even aiding access to venture capital.

BARRIERS TO UNIVERSITY-INDUSTRY COLLABORATION

In most cases, there has been insuficient experience to determine whether these recent government efforts to promote industry ties have been successful. A recent survey of industry-university-government collaborations, for example, indicates that 105 out of 138 such collaborations have been founded in the past 5 years.[8] Each year has seen an increasing number of such collaborations. There is little literature, however, on the consequences of such collaborations, or their implications for university independence.

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[7] Langenberg, op. cit., p. 19.

[8] Helen D. Haller, "Examples of University-Industry-(Government) Collaborations," Ithaca: Cornell University, Aug. 1, 1984.

What evidence there is suggests that, notwithstanding the benefits of such collaborations, there is no easy route to success. The university connection is no complete substitute for a vigorous, in-house research program or for entrepreneurial talent. On the other hand, the industrial dollar is not simply money; it often comes with certain stipulations that influence university research activity. The following paragraphs describe some of the most important issues affecting industry-university collaborations, from the industry, university and governmental standpoints.

The primary difficulty stems from the traditional roles of industry and university. The former is oriented toward production and markets; much of the product and market information it employs is proprietary; many of the problems it must solve are multidisciplinary; and its employees are rated on the basis of their "commitment to deliverables." Universities, on the other hand, are oriented toward instruction and the pursuit of knowledge; they are dedicated to the publication of research findings; their academic departments, and research activities, are organized by discipline; they are satisfied in their research goals to employ a "best effort," rather than "commitment to deliverables" standard.

Most university personnel must divide their time between instruction and research. This means that industrial researchers who are employed full time find the pace of university research rather slow. A related problem, discussed below, is that few universities can afford the new generation of expensive equipment that could speed research results.

Modern, advanced technology research is expensive. Furthermore, it is virtually impossible for any one university to afford the purchase and maintenance of equipment that will make it a center for scientific/engineering disciplines at once. One large university specialized research center, for example, enjoys a $3 million State commitment for the purchase of equipment only. Most of this equipment is beyond the reach of other universities, but is in common use in large industrial firms. Newer generations of equipment not only enable more rapid research turnaround; they are also more sensitive in their reading of data; permit greater accuracy where extremes (e.g., of temperature and pressure) are required; and automatically perform calculations that might otherwise have to be done by hand.

This poses a problem for universities, which must choose the scientific and engineering areas where they will concentrate their resources. It poses a corresponding problem for industrial firms, which must often establish ties with several universities in order to gain benefits from university research related to the full range of the firms' activities. At the Government level, critical choices about grant allocation for industry-oriented research must be made based upon a sober assessment of each university's ability to contribute substantially to the body of knowledge in a particular field.

In industrial research, key data are often utilized and even generated during the research phase of product development. If this research is performed at a university, the issue of proprietary information, and the publication of research results and data, come to the fore. Many cooperative research arrangements have disposed of this issue by allowing for university research results to be delayed, or by preventing students from having access to proprietary data. Nevertheless, there is considerable suspicion on the part of industrial firms as to both government and university publication of proprietary information.

Despite recent legislation permitting industrial research partnerships without violation of antitrust laws, the spectre of antitrust sanctions interferes with more productive industry-university relations. There are incidents where industry personnel attending a university meeting have asked the professional staff to sign documents attesting to the meeting agenda, the identity of other attendees, etc.

The research and development tax credit comes up for renewal in 1985. While it has tended to promote more research, and more industry-university joint research, there is little documentary proof of this. Some industrial research directors believe that failure to renew this tax credit could substantially impair this country's fine recent record in high-technology research, and nip certain industry-university consortia in the bud.

The demand for scientists and engineers is such that bachelor's degree holders often find it more lucrative to find work directly out of college, rather than pursuing further graduate study. Additionally, graduating science and engineering researchers can often be attracted to a firm because of the prospect of working on state-of-the-art equipment that few universities can afford. As a result, the number of U.S.-born graduate students in scientific and engineering disciplines has fallen substantially since the mid-1970's peak.

CONCLUSION: HOW CAN WE MAXIMIZE THE BENEFITS?

The first three sections of this chapter describe the emerging role of academic research in an industrial setting and the opportunities/problems, respectively, of industry-university relations. The fact that there should be a strong partnership is a peculiarly American phenomenon, based in part upon the success of the land grant college system. Unlike the European system, where academic customs are given greater emphasis, both public and private universities in this country are often chartered in part to promote commerce matching barriers with incentives.

Until recently, the primary interest that business firms might have in establishing university ties was in being assured a reliable supply of skilled professional manpower. The first two sections of this chapter indicate, however, there is a potential for substantially more productive ties than the traditional one of the university as a recruiting ground for new graduates. The smaller, high-tech firm, which is one of the concerns of this report, has needs that go well beyond (and possibly do not include) recruitment.

Recent research has identified several characteristics or personalities that are present in firms that consistently develop commercially successful product innovations, especially innovations that are dependent upon advanced technology. These include:

1. The innovator, or idea person, whose creativity and research expertise regularly generate ideas that have commerical potential;

2. The manager/salesman, who "runs with the ball," often having to sell a new product or process to investors and executives who are uncomfortable with change;

3. The "technological gatekeeper," who keeps the company informed of technological advances elsewhere that are relevant to the firm's profitability;

4. The "market gatekeeper," who transmits customer needs and behavior back throughout the firm (related research indicates that a high percentage of product innovation in high-technology fields is customer-driven); and

5. The "manufacturing gatekeeper," who sees to it that new products are designed for manufacturability.

A small, newly formed firm must often combine two or more of these personalities in a single person. Government data indicate, for example, that one-half of all high-techology firms in this country have fewer than 20 employees. If a firm's major asset is simply a commercially exploitable idea, therefore, this still leaves it lacking in necessary skills and resources for making the firm prosper and continue to grow.

An increasing number of universities and State legislatures are coming to realize that a university is well situated to fill these gaps between a firm's existing resources and what it needs to compete in the marketplace. As the above analysis implies, however, this means paying critical attention to the traditional role of the university. Thus, there are at least 21 university-based centers that serve as "incubator" facilities and/or help firms obtain access to capital. At least 17 of these have been founded in the past 5 years.[9]

Chart 7 below sets forth the obstacles or problems associated with promoting better industry-university cooperation, described in this chapter and matches them with the incentives or interests that were described in chapter II. For example, the bottom line of the chart, "number of U.S.-born grad students in sci/eng is down," has implications for the national interest in maintaining a vigorous domestic scientific and engineering establishment; thus, an "X" connects it to the incentive/interest on the horizontal axis "Nat'l Interest in Sci/Eng."

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[9] Information from Haller, op. cit., and field visits.

CHART 7

	Convergence of indus/ univ interests	Public interest in high-tech growth	Shifts in traditional roles	New ideas have grown from univ setting	Small firms can piggy back univ facilities	State/Fed programs leverage indus dollar
Traditional roles of academe, industry	X	X	X	X		
Univs must balance teaching and research	X	X	X		X	
Modern research equip't is expensive		X			X	X
Univs cannot be leaders in all sci fields	X					
Proprietary data problem	X		X			
Antitrust threats inhibit more coop		X				
R&D tax credit: will it be renewed?		X				
#of US-born grad students in sci/eng is down		X				

The chart illustrates that paying attention to such incentives could go a long way in maximizing the benefits from closer industry-university relations. It also indicates that one of the largest perceived problems—lack of money—bears a close relation to several incentives and is where a national program for dealing with these issues might start.

The important aspect of industry-university relations is that closer ties are in the interest of several parties: the industrial firm (including the smaller, high-tech firm), the university, the State and local government, and the Federal Government. The cross fertilization of ideas that is important to the basic function of the university is also critically important to the continued development of basic and applied science. If this principle is not disturbed by government policies, it will rebound to the benefit of academia, U.S. industry, and the national economy.

IMPLICATIONS FOR FEDERAL POLICY

The technological sophistication of the United States today, which is due in large part to the impressive achievements of American scientists and researchers at universities, is being severally challenged by the rapid utilization of new technology by America's international trading partners. In many cases, foreign firms have gained a competitive advantage by paying better attention than American firms to new technologies and rapidly adopting them. This has been especially true with regard to advanced manufacturing technology, which is in more widespread use in Japan than in the United States.

This technological basis of industrial competitiveness has reemphasized the need for a better connection between basic research activities and commercial ones; between the university and the industrial researcher. Too close an alliance, however, may be detrimental. If a university cannot maintain its independence from an industrial sponsor, it becomes more and more like an industrial research department.

Experience has shown that the most constructive industry-university collaborations occur when there is a mutual understanding of the unique roles played by each party. This kind of understanding usually takes time, as it is personality-based and often depends upon a deep understanding of each party's motives and ways of doing business. Notwithstanding the difficulties involved in industry-university collaborations, the commonality of interest virtually requires a high degree of cooperation in order that the goals of both institutions be realized.

Federal Government policy, if misdirected, has a potential for frustrating these goals. This is because Washington has the power to redirect a substantial percentage of research resources, which are in fact limited. If this Federal direction does not accord with the overall national interest, the country could end up with a technology-short industrial base.

Legislation is often proposed that would have the Government take the lead in developing commercial technologies. Such legislation is motivated by the sincere belief that some technological areas are "leading" sectors, and key to U.S. industrial competitiveness. Bringing the Government in as a sponsor of basic and applied research in these areas could give America a critical technological edge on the rest of the world. It draws from what some people believe is the proper role of government: picking technological "winners" in the race for trade supremacy, and bringing government resources to bear on promoting these technologies.

Should the Government need such technologies as a consumer, such research can be useful. Indeed, this is done on a regular basis, through research contracts led by various agencies such as the Department of Energy, the National Aeronautics and Space Administration, and the Department of Defense.

The Federal Government, however, would be ill advised to attempt to create technology that may or may not be commercially useful. Experience has shown that government-induced demand often distorts market realities. The history of supersonic transport provides a conspicuous example, but numerous smaller ones exist as well.

The industry-university collaboration route to technology development takes another, more reliable, approach. In such a case, the demand for technology is being generated by the end user; industrial firms pick the winning technologies. Their choice may be mistaken in some instance, but it is always made with an aim toward the most efficient allocation of resources.

The United States has a unique system of housing basic research at universities and relying on industry to develop technology and new products from basic research. Within the American system, a rough division of labor has proven to be efficient. To a large extent, the health of basic research in the United States—and the lure of industry to academe—depends upon Federal Government funding for basic research at universities.

As stated, universities and industry have been developing new collaborative mechanisms to help spread the development and transfer of technology into the marketplace. While the primary force for the emerging role of academe is the increasing technological sophistication of the American economy, a number of important public policies have been encouraging and facilitating the trend. More generally, public policies that promote a more competitive economy, such as open trade policies and deregulation of domestic industries, by raising the need for commercial R&D to remain competitive, are encouraging industry to seek out collaborative research efforts with universities. Concern over declining student enrollments has prompted universities to be more aggressive in pursuing industry research for funds to maintain and strengthen their academic departments. Also, growth in real Federal funding for basic research is contributing to the attractiveness of universities as a source of new ideas for industry.

The primary policy recommendation of this chapter is to continue to promote market based collaborations with minimal Federal interference. The policies already in place are factors in the emerging role of academe in the Nation's overall climate for entrepreneurship and innovation, but more can be done. In the interest of accommodating and facilitating university-industry collaboration, Federal policy should:

1. Make permanent the incremental R&D tax credit due to expire in 1985, and include software development in the base;

2. Make deductions of equipment donations to universities for research *and* teaching more generous;

3. Promote and encourage joint R&D ventures, and remove any unnecessary regulatory barriers to university-industry collaboration;

4. Maintain strong Federal Government support for basic research at American universities, and ensure that these funds continue to be allocated on the basis of scientific merit (commercial interests should drive collaborative research but not basic science at universities);

5. Move to a more simplified tax structure but preserve incentives for risktaking and commercial R&D investments;

6. Federal departments and agencies should consider the potential benefits to the economy from collaborative research with universities and industry, as well as efficiency in meeting their mission requirements (one objective of agency collaboration with universities and industry, whenever appropriate, ought to be to speed the process of commercialization of technology developed for government purposes); and

7. Establish a nationwide program to make educational, nonsubsidized loans available to college students, regardless of family financial circumstances, so that no person would be denied an advanced education because of lack of financial resources. The principle and interest would be repayable upon obtaining employment or graduation plus 6 months and automatically collected in equal installments by the Internal Revenue Service until paid in full.

The policy recommendations outlined in this chapter are designed to further technological innovation by encouraging the main actors in that process—universities, government, and industry—to continue to work collaboratively in the development of technologies relevant to the interested parties and to society. The authors believe that university-industry-government collaboration, properly structured and nurtured, provides a viable alternative to federally funded "generic technology center," patterned after agriculture experiment stations, as a means of ensuring continued American technological leadership.

University-industry collaboration reflects private sector interests and not the wishes of government planners. Also university-industry collaboration offers the potential to strengthen the academic mission of the university, on which government *and* industry depend for a technically and professionally competent task force. In general, how Federal Government expenditure, tax, and regulatory problems affect university-industry collaboration will have a significant impact on the rate and direction of technological innovation in the American economy in the years ahead.

IV. GOVERNMENT LABORATORIES AND ECONOMIC DEVELOPMENT

Concern over U.S. technological leadership has led to an interest in the potential of the Federal laboratory system to improve technological innovation. This chapter examines the opportunities and obstacles to technology transfer from Federal Government laboratories to the marketplace. Federal laboratories acquire and develop technology to meet mission requirements—defense, energy efficiency, and environmental protection, but the challenge of public policy—examined in the following sections—is to find ways to speed the flow of technology and expertise to the commercial sector, without sacrificing mission requirements.

Much of the discussion in this chapter is based upon expert testimony before the Joint Economic Committee in its August 7, 1984, hearing on the "Role of Government Laboratories in Regional Economic Development." The expert witnesses at that hearing were The Honorable Clarence Brown, Deputy Secretary, Department of Commerce; Col. Paul J. Theuer, Commander and Director, Construction Engineering Research Laboratory, Champaign, IL; Dr. George Dacey, President, Sandia National Laboratories; Mr. Charles Miller, Lawrence Livermore Laboratory; and Dr. Edward Melecki, University of Florida. Discussions with the Federal Laboratory Consortium for Technology Transfer and the National Aeronautics and Space Administration were also helpful.[1]

NATURE OF THE ISSUE

The current interest in improving economic conditions at national, regional, State, and local levels has focused attention on increased utilization of the resources of the Federal Government. For the past 10 to 15 years, the Federal laboratory system has served as a technical resource to assist State and local governments in addressing technology-oriented problems they have encountered in the provision of services to the public. For example, to aid in energy conservation, Federal labs have provided heat sensing expertise and equipment for flyovers of public buildings to identify costly heat loss. A computer system developed by the Navy was adapted and applied to assist the New York City police department in monitoring the use of gasoline in squad cars. And, in a cooperative effort to meet a public need, the National Bureau of Standards and the Army Edgewood Arsenal worked with Du Pont and local police departments to develop a bullet proof vest which has saved many lives.

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[1] "Government Laboratories and Economic Development," from Part 1 "Climate for Entrepreneurship and Innovation in the United States," hearings before the Joint Economic Committee, U.S. Congress, Aug. 7, 1984.

In the past several years, as more attention has focused on increasing innovation in the private sector, the Federal laboratory system has also been viewed as a resource for technology and technical expertise which can be utilized by both large and small companies. As was indicated in the testimony,[2] various technologies developed in the Federal labs have been transferred to firms where they can be further developed, used and/or commercialized. The Department of Energy's Pacific Northwest Laboratory (run by Battelle) developed ionic additives for paints, a technology which was subsequently transferred to a small local company which it was commercialized. This additive puts a "finger print" on tools used in the oil industry and can be used to detect and identify equipment which has been stolen. In another example, the Army Corps of Engineers developed a computer software system called "Blast" which allows for the assessment of building energy efficiency early in the design process. This system is being utilized by companies such as McDonnell Douglas, Control Data Corp., and Boeing Computer Services, as well as by other firms throughout the world.

As State and local governments look toward innovation-related activities to encourage economic development in their regions, there has been increasing interest in networking the resources of the States, the private sector, and Federal laboratories. In an attempt to create an entrepreneurial environment within the State, the University of Tennessee and Martin Marietta Energy Systems, which runs the Department of Energy's Oak Ridge National Laboratory, have jointly created a Measurement and Control Engineering R&D Center. This center has commitments of $50,000 per year from nine companies including Gulf, Dow Chemical, Olin, Ford, International Paper, Texas Instruments, Koppers, Alcoa, and Robertshaw Control. And in New Mexico, a community project, with funding from the private sector, and with technical expertise provided by Los Alamos National Laboratory, has lead to the creation of an incubator center which will open with 80 percent occupancy in early January. Many of the companies which will locate there are spinoffs from the Federal laboratory and this increased business activity should benefit the local economy.

Public Law 96-480, the Stevenson-Wydler Technology Innovation Act, which mandated technology transfer from the Federal laboratories to the private sector, as well as to State and local governments, was passed in recognition of the positive role Federal laboratories can have in economic development. In this manner, public funds spent in the Federal lab system can have an impact beyond the original intent of the initial investment.

Cooperation in creating an entrepreneurial environment can benefit all the participants. As Congressman Daniel E. Lungren, who chaired the Joint Economic Committee hearings on this issue, stated in his opening remarks:

> The central question concerning America today is how to encourage technological innovation so our economy can compete. . . . The use of the resources and expertise of the

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[2] U.S. Congress. Joint Economic Committee. Hearings on "Climate for Entrepreneurship and Innovation in the United States," part 1, 2d sess, 98th Congress.

> Federal laboratory system is one way to foster this innovation. The improved flow of technology from government research can be an important component of . . . national innovation policy.[3]

TECHNOLOGY TRANSFER DEFINED

The Federal laboratory system has extensive science and technology resources developed as a consequence of meeting the mission requirements of parent agencies. It is thus a potential source of technology and technical expertise which can be utilized in the business community. A portion of the body of knowledge and the store of technologies created in pursuit of the agency's mission may have commercial application beyond the original useage. However, the Federal Government does not have the authority and/or ability to further develop, adapt, and commercialize the results of this R&D endeavor. Thus, there is interest in transferring technology to the private sector which has the resources to undertake such activities.

Technology transfer is the process by which technology developed in one organization, in one area, or for one purpose is applied and utilized in another organization, in another area, or for another purpose. Some of the technologies resulting from the Federal Government's sizable investment in research and development may be amenable to transfer to the private sector where they can be further developed to meet market demands and create new and different products and processes. Through the transfer of technology, new solutions to the increasing number of technologically oriented problems can be made in both the public and private sectors.

The value of technology transfer becomes evident when it results in the commercialization of a product or process. Commercialization is a critical step in the innovation process in that it is the activity by which an idea or invention becomes a marketable good or service. It is vital to the promotion of economic growth since the economic benefits of innovation accrue when a product or process is brought to the marketplace where it can be sold or utilized to increase productivity. While the Federal Government directly funds basic research and that applied research necessary to meet the mission requirements of the Federal departments and agencies, commercialization is the responsibility of the private sector.

THE FEDERAL INTEREST

The Federal interest in technology transfer stems from several different concerns, one of which results from the need to buy products and processes, goods and services to meet the operating requirements of the Government. As noted by Colonel Theuer in his testimony, "within the military system, technology transfer means taking that extra step in the R&D process to assure that the R&D product gets into the hands of the military users." Unless industry manufactures the item . . . the Army and Defense Department cannot buy it." The needs of the Federal Government have successfully spawned entire new industries as evidenced by the aviation and computer industries, as well as helped older established industries by requiring an ongoing supply of equipment related to national interests or security.

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[3] Ibid., p. 1.

The Federal Government's involvement in technology transfer also arises from the recognition that the economic well-being of the Nation is affected by the commercialization activities of the business community. It is often said that the United States has the best basic research enterprise in the world (as evidenced by the number of Nobel prizes awarded to U.S. scientists), but other countries—most notably Japan—often appear more adept at taking this research and making marketable products. Many times Americans end up purchasing foreign made goods developed out of research performed in the United States. As Dr. Dacey testified, in some cases ". . . the foreign competitors are more anxious or at least as anxious to have our [laboratory] technology transferred to them as our own industry is."

Innovations resulting from the transfer of technology can promote economic growth through increased productivity. The work of Edward Denison has demonstrated that from 1948 to 1973, "advances in knowledge (including technical amd managerial knowledge) are the biggest and most basic reason for the persistent long-term growth of output per unit input." [4] Richard Nelson has asserted that industrial innovation has played a central role behind longrun rises in productivity and living standards and has impacted upon the composition of employment, the structure of industry, and the pattern of imports and exports.[5] Similarly, John Kendrick estimated that approximately two-thirds of U.S. industrial growth measured in real gross product per labor from 1960–73 was attributable to technological advances including changes in labor quality resulting from increased education and experience.[6]

The manufacture of goods, based on the transfer of technology from the Federal Government to the private sector, also helps to foster regional economic development. Colonel Theuer testified that when a technology is transferred to the private sector for commercialization ". . . there are secondary effects such as job creation and the development of domestic markets which promote regional economic development." He explained that a patent licensed by the Corps of Engineers for a ceranode will generate a 5 percent royalty for the U.S. Government, increase the work force of the company doing the licensing from 30 to 142 employees, and increase the firm's sales by an estimated $8.5 million. "Thus," Theuer stated, "technology transfer not only results in reduced manufacturing and operating costs by users of these licensed devices, but also generates jobs in the private sector and royalties for the U.S. treasury.

Deputy Secretary Brown of the Department of Commerce noted that "the best way to get more new technological products for regional economic development, national growth, and international competitiveness . . . out of the dollars spent on the Federal labs is to open their doors to collaboration with the private sector." The

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[4] Edward Denison, "Accounting for Slower Economic Growth," The Brookings Institution, 1979, pp. 79–80.

[5] Talk presented at CRS seminar. Washington, D.C., June 18, 1980.

[6] John Kendrick, "Sources of Growth in Real Product and Production in Eight Countries, 1960-1978," N.Y. Stock Exchange, 1981.

States have recognized the regional economic benefits to be derived from science and technology and are creating high-technology research and industrial parks to enhance the development of new enterprises in these areas. The Federal system has a role, as Brown sees it, in that "for new businesses and jobs to be created much of the technological base will have to come from the Federal labs." As an example, Miller cites a program at the NASA Industrial Applications Center in Pennsylvania which is sponsored by the local economic development commission. Workshops are being held with Federal laboratory and industry representatives to link resources on a one-to-one basis with the assumption that new technologies will be developed which will contribute to the economic vitality of the area.

While the other witnesses are enthusiastic as to the benefits of utilizing the Federal laboratory system, Maleki's studies point to what he sees as limitations on the impact Federal laboratories can have on regional economic development. Noting that at the current time most Federal R&D is defense related, he asserts that much of the technology developed is not transferrable. According to his testimony, Federal laboratories have generally failed to attract or spin off industry. Regional economic development occurs when there is an "agglomeration" of different R&D-related enterprises including industry, universities, venture capital, and Federal labs which contribute to the existing research and development infrastructure. Thus, Maleki maintains that Federal R&D only has a "notable" effect on regional economic development in large urban areas because Federal R&D funds are spent at firms in a relatively small number of locations which can attract competent personnel. While small, isolated Federal laboratories may generate a small amount of innovation, most innovation leading to economic growth will occur in "existing clusters of entrepreneurial activity."

THE TRANSFER PROCESS

The transfer of technology can be a long and laborious process. It begins with an attempt to identify what knowledge or technology is appropriate for transfer—what has potential for commercialization—and ends when a good or service is made available in the marketplace. The gap between the work performed internal to the laboratory and the industry which can produce a finished product or process from laboratory technology is a difficult one to bridge. It cannot be the sole responsibility of the Federal Government. While the labs serve as a resource, what is necessary, in view of the testimony presented, is a cooperative effort between the States, the Federal Government, the private sector, and often universities.

Networking is imperative. The problem, as Deputy Secretary Brown sees it, is that a successful transfer requires links to be made between parties which are unaccustomed to working together. The means to foster these links must be strengthened. While the National Technical Information Service of the Department of Commerce was created to provide information concerning expertise and technologies available within the Federal laboratory system, Brown states that more has to be done in this area because ". . . one of the difficult things that the Federal Government has to do and doesn't always do well, is to relay information from the Government to the private sector." The Government should develop improved mechanisms to allow for the identification of technology and expertise within the Federal laboratories and find ways of making this information known to the business community. Conversely, and simultaneously, the private sector has responsibility to assist in assessing and identifying the commercial viability of federally funded R&D and should be more receptive to the transfer efforts of the Government.

If regional economic development is a goal, States are critical players in the transfer of technology from the Federal laboratories. States act to attract business and, Dacey noted, the labs are a source of technology to support State-industry initiatives. States can augment the transfer process by acting to bridge the gap between laboratories and the private sector and to help industry identify Federal R&D resources. As Colonel Theuer testified, laboratories ". . . need to work with the States, who have begun to develop organizations, often around a university base, to find available technologies in government labs that are transportable to their respective States in support of local and regional development."

In the process of networking, it is important to consider that transfer of technology has the best chance for success when it is undertaken on a case-by-case basis. "Champions" in both the laboratory and in industry are necessary to guide the process through from the lab to final commercialization in the private sector. Dacey points out that technology transfer succeeds when ". . . both parties' mutual self-interest are being met." This provides the process with the committed personnel necessary for achieving a successful transfer. When these mutual needs are met it becomes, as Dacey describes, a "win-win" situation. The laboratories transfer technology and thereby are able to insure that parts, equipment, and systems are available for purchase. Private companies have goods to sell to the Government and can develop other products and processes for additional markets. Thus, it is to the benefit of all concerned that the technolgy transfer process is facilitated by all participants.

CURRENT FEDERAL ACTIVITIES

Over the years several Federal efforts have been undertaken to address the technology transfer issue. The Federal Laboratory Consortium for Technology Transfer (FLC) was created in 1974 (from a Department of Defense program) to assist in transferring technology from the Federal Government to State and local government and the private sector. The primary purpose of the consortium—a voluntary organization of almost 300 Federal labs—is to coordinate and facilitate the transfer of technology and to promote the effective utilization of the technical knowledge developed within Federal departments and agencies. In order to accomplish the goal of increased utilization of Federal R&D, the Consortium establishes channels of communication and interaction between Federal agencies and potential users at other Federal departments, at the State and local level, at nonprofit broker organizations, and in private industry. These networks create the means through which user requirements can be identified, delineated, and addressed. The Consortium also provides the means by which innovations can be made available to the private sector for further development and marketing to the public.

In commercialization of federally funded technology, the Consortium advertises innovations available to the private sector for additional development. In some instances, the Consortium simultaneously serves as a broker between State and local units, Federal agencies, and private industry to promote cooperation on a project. One successful effort of the networking that witnesses identified as essential to the transfer process involved the development of a bullet-proof vest for law enforcement officials. In this case, the FLC identified a need of local government and was successful in bringing together the resources of the Federal Government and the expertise of private business to secure the design and manufacture of a product vital to local needs. This was accomplished by Federal employees working with State and local officials and industry representatives on a one-to-one basis.

To expand on the work of the Federal Laboratory Consortium, and to provide added emphasis on the commercialization of Federal technology, Congress passed Public Law 96-480, the Stevenson-Wydler Technology Innovation Act of 1980. Prior to this law, technology transfer activities were not an explicit part of the mandate of the Federal departments and agencies with the exception of the National Aeronautics and Space Administration. To provide "legitimacy" to the transfer function, Congress, with strong bipartisan support, enacted Public Law 96-480 which requires that:

> It is the continuing responsibility of the Federal Government to ensure the full use of the results of the Nation's Federal investment in research and development. To this end the Federal Government shall strive where appropriate to transfer federally owned or originated technology to State and local governments and to the private sector.

Section 11 of the law creates a system within the Federal Government to identify and disseminate information and expertise on what technologies or techniques are available for transfer. Offices of Research and Technology Applications were created in each Federal laboratory to distinguish technologies and ideas with potential applications in other settings. This information is required to be forwarded to the newly created Center for the Utilization of Federal Technology (CUFT) at the Department of Commerce. CUFT's responsibilities are to serve as a focal point for access to the system, to disseminate information on the availability of federally generated technology, and to provide whatever additional assistance is necessary to transfer the technology. The Center has been placed under the National Technical Information Service (NTIS) at Commerce. NTIS has had the ongoing function of collecting and disseminating (on a cost recovery basis) information on all federally funded research and development projects. However, as noted previously, Deputy Secretary Brown questioned the effectiveness of the National Technical Information Service and Miller cited a new study which showed that the two primary users of NTIS were the

Soviet Union and Mitsubishi. Thus, the issue remains, what can be done to further develop the environment within which American firms, as well as State and local governments, will be willing and able to better utilize the Federal laboratory system.

IMPROVEMENTS TO THE TRANSFER PROCESS

The consensus at the Joint Economic Committee hearings was that the Stevenson-Wydler Technology Innovation Act has made a contribution to the promotion of technology transfer, but that more can, and should be done. Deputy Secretary Brown testified that the law has helped encourage technology transfer in that it makes such activities a matter of national policy and therefore is a basis for Federal action. However, Stevenson-Wydler has not solved all the problems, according to Brown. He argues that the laboratories still do not perceive the legislation as providing them with the authority to enter into transfer agreements with the private sector. Therefore, Brown recommended that Congress pass further legislation which provides clear authority, at the laboratory level, for the transfer of technology and which permits patent licensing decisions to be made with the labs themselves as opposed to at the agency level. The laboratory mission should include activities to foster commercialization by the private sector. Each laboratory should have, what Brown terms, the "broadcast authority possible" to develop a working relationship with industry.

The other witnesses testified, however, that Stevenson-Wydler does provide the laboratories with the clear authority to pursue the transfer of technology to the private sector. As Dacey related, the mandate to transfer technology inherent in Public Law 96-480 has placed a formal emphasis on technology transfer. It legitimizes the transfer activities which were undertaken prior to the law, and encourages laboratories where there was little or no transfer to make a concerted effort in this area. Yet, while Theuer, Dacey, and Miller all agreed that Stevenson-Wydler provides the technology transfer mandate, they stressed that it does not provide the incentives to pursue such activities. What is essential is the development of incentives for individuals within the laboratories to work on the transfer process and which encourages industry personnel to seek and accept the technology for transfer and eventual commercialization.

Speaking to the importance of personal commitment to see a transfer through to completion, the witnesses suggested that an environment be created that would foster the dedication of laboratory personnel and the development of "champions." Dacey indicated that the most effective incentive to creating this type of atmosphere within the labs is to augment the feeling of accomplishment associated with successful transfer rather than to provide monetary rewards. It is management's responsibility to project the idea that technology transfer provides a positive and essential contribution to the laboratory' mission. Similarly, Miller indicated that nonmonetary incentives such as personnel commendations can be very effective. He concurred in the importance of top management's commitment to technology transfer, but pointed out that there are no incentives, and several consequences, for innovative behavior on behalf of laboratory administration. He suggested that management must operate in such a way as to underscore the importance of the mission requirements of the Federal department or agency.

Additional suggestions were made concerning the development of an environment within the Federal laboratories which would foster the transfer of technology. Brown recommended that conflict of interest rules be changed to permit Federal lab personnel to pursue projects of interests on their own time without forfeiting their Federal jobs. It was also suggested that the individual inventor within the laboratory receive royalties once a technology has been successfully commercialized. Similarily, another idea would be to permit the royalties collected by the Government to go directly back to the laboratory which effected the transfer to be utilized for other ongoing R&D projects.

There are other barriers to the transfer of technology which are not addressed in the Stevenson-Wydler Act, but which are seen as significant by practitioners in the field. Among these are problems associated with conflicts of interest and related legal questions. The Federal Government, and consequently the laboratories are prohibited from competing with the private sector. Thus, as Dacey pointed out, it was unclear whether joint ventures between Federal laboratories and State or local governments or industry could be construed as conflicts of interest. To encourage further risktaking in the promotion of technology transfer it is necessary to clarify those questionable areas regarding the legality of activities involved in the transfer process. He noted that it took over a year to determine issues of legal liability on just one transfer effort. These are difficult problems, but they must be addressed in order to facilitate the transfer process.

Despite the potential offered by the resources of the Federal laboratory system, the commercialization level of the results of federally funded research and development has remained low. Research indicates that only approximately 5 percent of federally owned patents are ever utilized. From the perspective of industry there are many reasons for this low level of transfer, one of which is the fact that many technologies have no commercial application. However, industry unfamiliarity with Federal technologies, the "not-invented-here" syndrome, and perhaps most significantly, as discussed below, the ambiguities associated with obtaining title to or exclusive license to federally owned patents also contribute to the limited levels of transfer.

Promotion of invention and commercialization of technology is one major objective of the patent system and in most cases this goal is furthered by government policy and practice. However, one aspect of government patent policy—that which pertains to inventions made under Federal funding—has come under criticism as an impediment to technology transfer. In most cases (with the exception of universities, small businesses, and not-for-profit institutions), title to inventions made with Federal monetary support is vested in the Government. The Government's financial contribution to research and development has resulted in the generation of over 28,000 patents. A portion of these patented ideas have potential for further development, application, and commercialization.

Yet, as noted above, research has shown that only approximately 5 percent of government-owned patents are ever introduced into the private sector.

Critics of the present system assert that government policies concerning ownership of title and nonexclusive licensing practices have resulted in this low level of commercialization and use of federally owned patents. As Dacey testified, industry needs proprietary rights if it is to undertake commercialization. The argument proposes that, without title to an invention and the 17-year exclusivity it provides, an individual or company will not invest the time and money necessary for the development of a marketable product.

The Congress has accepted to a limited extent the contention that vesting title to the contractor will encourage technology transfer and commercialization. Public Law 96-517, Amendments to the Patent and Trademark Laws, provides, in part, for title to be vested in contractors if these are small businesses, universities, or not-for-profit institutions. Certain rights are reserved for the Government and these organizations are required to commercialize within a predetermined and agreed upon timeframe. Yet it continues to be argued that patent exclusivity is important for both large and small firms. In this spirit, President Reagan issued a memorandum in February 1983, which instructed all Federal departments and agencies to treat, as allowable by law, all contractors regardless of size as prescribed in Public Law 96-517 with regard to the ownership of title.

It has been suggested that to further encourage this transfer effort, patent licensing authority be given to the individual laboratories. As Brown testified, the issuing of licensing at the agency level tends to increase bureaucratic complications which can be avoided by giving patent responsibility to the specific laboratories involved in the transfer process. This concern was addressed in the closing days of the 98th Congress. Title V of Public Law 98-620 makes certain amendments to the Patent and Trademark laws which should improve the transfer of technology from the Federal laboratories to the private sector and increase the chances of successful commercialization of the results of federally funded research and development. This law permits Federal laboratories to make decisions at the laboratory level as to the granting of exclusive licenses for government-owned patents. This has the potential of effecting greater interaction between laboratories and industry in the transfer of technology. Patent royalties are also permitted to go back to the laboratory or university (in the case of government-owned, contractor operated labs (GOCO)) to be used for additional R&D, awards to individual inventors, or education. While there is a cap on the amount of the royalty returning directly to the lab in order not to disrupt the agency's mission requirements and congressionally mandated R&D agenda, the establishment of discretionary funds gives laboratories added incentive to encourage technology transfer.

Several other provisions of Public Law 98-620 can be foreseen as meeting some of the concerns expressed during the Joint Economic Committee hearings. Private companies, regardless of size are allowed to obtain exclusive licenses for the life of the patent. Prior restrictions allowed large firms use of exclusive license for only 5 of the 17 years of the life of the patent. This should encourage improved technology transfer from the Federal laboratories or the universities (in the case of university operated GOCO's) to large corporations who often have the resources necessary for development and commercialization activities. In addition, the law permits GOCO's (those operated by universities, nonprofit institutions or small businesses) to retain title to inventions made in the laboratory within certain defined limitations. Those laboratories operated by large companies are not included in this provision. Under Public Law 96-517, the operating units of GOCO's were specifically prohibited from obtaining title.

Summary and Recommendations

The Federal laboratory system has been a subject of increasing interest in public policy discussions on how to preserve U.S. technological leadership. Finding ways to improve the flow of technology and expertise from Federal laboratories to the commercial sector is seen in this study as an important component of a comprehensive strategy to improve the Nation's climate for entrepreneurship and innovation.

Many Federal policies are now in place to improve technology transfer, but apparently much more needs to be done. Some important Federal actions include the Stevenson-Wydler Innovation Act of 1980 and changes in U.S. patent policies. The former provides a congressional mandate—and authority—for Federal Government departments and agencies to seek ways to speed the commercialization of technology developed under Federal contract or in government laboratories. Important actions to date include the establishment of the National Technical Information Service and the Center for the Utilization of Federal Technology within the Department of Commerce and the authority to establish Offices of Research and Technology Applications in major Federal Government laboratories. Many laboratories have responded to their new authority and responsibility, but the consensus of expert opinion before the Joint Economic Committee is that lines of authority and incentive structures are inadequate. Much more can and needs to be done to maximize the commercial benefits from Federal laboratory research.

The primary deficiency of the current system of technology transfer is the lack of explicit incentives at the laboratory level to network with private businesses, universities, and State and local governments. Also, although the authority is there, many tough legal and potential conflicts of interest problems arise. What are the rights and responsibilities of government employees in working with industry on technology transfer? What are the antitrust implications of government laboratories working directly with industry? How should patent and royalty fees from successful technology transfer programs be divided among the laboratories, employees, Federal agencies and departments, and the U.S. Treasury?

Probably the most significant new actions to improve the technology transfer process would be those that focus on establishing general guidelines for laboratory-industry collaboration. In addition, identifying responsibility for technology transfer at the agency level, and within laboratories, would be a significant improvement over the current arrangement. In general, providing maximum discretionary authority for technology transfer at the laboratory level—consistent with general Federal department and agency guidelines and oversight—would be desirable. The advantage of decentralized authority is that it allows each laboratory flexibility in designing and implementing technology transfer programs consistent with the mode of operation of the laboratory.

Changes in Federal patent policies to give title to inventions from federally funded research to universities, small businesses, and not-for-profit organizations provides a strong incentive to bridge the gap between laboratories—and universities—and the private sector. Establishing patent offices within Federal Government laboratories to enable them to lease or sell technology to the private sector needs to be the responsibility of each Federal laboratory. Sharing the fees from laboratory-industry collaboration could provide the much needed financial incentive for laboratory officials to take technology transfer seriously, and to reward those responsible for successful technology transfer. Currently, legal authority is already provided for these functions, but lacking guidelines for acceptable laboratory-industry collaborations, many laboratory officials and research scientists are reticent to experiment with new technology transfer approaches.

The following are this study's recommendations for strengthening the authority for technology transfer mandated in Public Law 96-480, the Stevenson-Wydler Innovation Act of 1980; clarifying legal and conflict of interest issues; and promoting networking between government laboratories, universities, industry, and State and local governments in regards to technology transfer:

1. Strengthen Authority for Technology Transfer

Provide a full-time professional staff position in the Office of Research and Technology Applications within each major Federal laboratory, with responsibility for technology transfer programs, networking, and providing patent and legal advice to management and laboratory employees.

Include technology transfer in management's job evaluations, job descriptions, and employee promotion policies.

Establish awards within the laboratory for the successful completion of technology transfer, including compensation for the laboratory and those individuals responsible for the successful programs.

Establish guidelines and conflict of interest regulations and rules regarding laboratory-industry collaboration, including rules and guidelines for laboratory employees working in industry.

Permit each laboratory to develop individual technology transfer programs which complement the mode of operation of the lab. (Each Federal department and agency should be required to establish explicit authority within laboratories under their jurisdiction for technology transfer.)

2. Legal Clarification

Clarify conflict of interest rules as they pertain to joint Federal laboratory private industry activities.

Clarify the legal rights and responsibilities of Federal laboratories in joint ventures.

Clarify conflict of interest regulations regarding Federal laboratory personnel (permit businesses on the side, consulting with private firms, allow equity interest in other companies).

3. Encourage Networking

Encourage Federal laboratories to participate in new and/or ongoing State/university/private sector programs.

Encourage States to create mechanisms to identify technology in Federal laboratories which either can be utilized in the States' provision of services or which can meet economic development needs.

Identify the Federal Laboratory Consortium as the primary coordinating organization for the promotion of technology transfer. Provide a statutory basis for the Consortium.

Improve the operation of the National Technical Information Service and the Center for the Utilization of Federal Technology as another networking mechanism.

To implement the study's recommendations, a Commission on Technology Transfer should be convened, by Congress, to establish the necessary operating guidelines and procedures. Laboratory directors and scientists, Federal department officials, business representatives, the Federal Laboratory Consortium, State and local officials, and other appropriate groups ought to be represented on the bipartisian Commission, which would be given the responsibility of recommending explicit guidelines and conflict of interest rules to encourage networking, technology transfer, and the dissemination of technical information.

V. STATE INNOVATION STRATEGIES

A discussion of the Nation's entrepreneurial climate would not be complete without considering the innovation strategies of State and local governments in response to the realities of the 1980's. The new strategies emphasize expansion of the high-technology industries—but not to the exclusion of other industries—and the transfer of technology throughout all the segments of society. In general, the "State high-tech involvement" is the spatial analog of the transformation of American industry and society to a much greater reliance on the high-tech and service industries.

The pursuit of high-tech activities by the States is consistent with the view that industrial innovation is the "wellspring" of economic progress in an information economy. Industries like computers, semiconductors, aerospace, chemicals, biotechnology, and telecommunications have a considerable job generating potential in their own right but the spread of advanced technologies to other industries, such as the services and basic manufacturing, has the potential to create many more jobs. It is probably safe to say that the lion's share of productivity growth and job expansion in the future will depend, directly or indirectly, on the computer and other advanced technologies.

The underlying theme of this chapter is that it is in the national interest for the States and regions to pursue development strategies consistent with technological change in the American economy and its realignment in international markets. Toward this end, the States are reorienting their development efforts to be consistent with the locational and expansion needs of high-tech companies. The engrained practice of chasing the "smokestack industries" with generous financial incentives has been giving way to a strategy that places much greater emphasis on problems encountered in product development, technology transfer, capital formation, and industrial innovation.

A common feature of the high-tech strategies, examined in this chapter, is their reliance on market incentives to encourage the necessary entrepreneurship and risktaking to exploit commerical opportunities resulting from basic and applied research. The States are taking significant actions to stimulate entrepreneurship and innovation by removing technical, labor market, financial, and other barriers to business expansion. To do this, many States are investing in basic research, improving university high-tech linkages, networking with government laboratories, improving venture capital financing for the State's fledgling entrepreneurial companies, and initiating regulatory reform. Above all, and most encouraging, the States appear to be making a long-term commitment; they are attempting to integrate and coordinate a wide range of State tax, expenditure, and regulatory policies to provide a better overall entrepreneurial climate.

The chapter proceeds by examining the leading issues involved in creating a climate for innovation and high-tech growth at the regional level. Then, the experiences of Utah, North Carolina, and Pennsylvania, in their attempts to create a better climate for entrepreneurship and innovation, are examined. The discussion is concluded with an overall assessment of the State and local high-tech movement and its implications for national public policy.

CREATING A CLIMATE FOR INNOVATION AND HIGH TECHNOLOGY

In discussing what a successful State and local government development strategy ought to look like, Roger J. Vaughan, a leading expert in regional economic development, had this to say:

> An economic development strategy must focus on the overall economic climate, and not waste resources on special incentives for new favored firms. It must encompass a broad range of policies including training programs, infrastructure development and capital mobility as well as a balanced tax structure.[1]

Which attributes of local communities are most important to their ability to attract, maintain, and nurture innovative businesses? George A. Reigeluth and Harold Wolman, in a 1979 Urban Institute study, present the following definition of competitive advantage:

> A community is said to have a competitive advantage in a particular economic activity, when the products of that activity can be sold at prices which simultaneously underbid the prices of similar commodities produced at other locations, and which generates larger rates of return for firms in that community than for similar firms in other locations.[2]

As a practical matter, comparative advantage depends upon the locational characteristics of a community (e.g., geographic location, labor force, natural resources, transportation, business climate, quality of life, etc.) and its access to markets.

An examination of the locational determinants of high-tech companies provides a starting point for evaluating the policy options available to States trying to encourage industrial innovation and high-tech expansion.

Until the Joint Economic Committee Survey of High-Technology Companies in the United States, knowledge of high-tech locational decisions was largely antedotal.[3] In all, 691 executives of high-tech companies responded to the survey. They represent companies in a wide variety of industries, including the telecommunication, medical equipment, computer research, semiconductor, aerospace, chemical and defense industries. California and Massachusetts were listed as home for 322 and 155 of the responding companies, respectively. The remainder were scattered throughout the other States and regions.

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[1] Roger J. Vaughan, "The State and Federal Role in High Technology Development," a paper presented at a symposium on Technology and Regional Development: The Policy Issues, Syracuse University, April 1984.

[2] George A. Reigeluth and Harold Wolman, "The Determinants and Implications of Communities Changing Comparative Advantage: A Review of Literature," Washington, DC: The Urban Institute, 1979.

[3] Robert Premus, "Location of High Technology Firms and Regional Economic Development," staff study prepared for the Subcommittee on Monetary and Fiscal Policy of the Joint Economic Committee, Congress of the United States, May 1982.

The JEC Survey defined high-technology companies as companies that rely on technological innovation to remain competitive. Companies that (1) employ a high percentage of engineers, scientists, and technicians in their work force, (2) are heavily dependent upon R&D inputs, and (3) are engaged in developing and marketing new products and services that embody the latest technology were included in the survey. In general, these unique characteristics of high-tech companies reflect their role as suppliers of new products and services made possible by advances in basic science. Since they operate at the early stage of the product development cycle, markets are not clearly defined and there are potential numerous technical, labor market, and finanical barriers to product development and firm growth. Consequently, market and technical risks are high, making access to skilled labor, research, and venture capital important factors in the overall climate for high-tech expansion.

Locational Determinants

The unique characteristics of high-technology companies are reflected in their locational requirements. (See Table V.1.) Not surprisingly, the availability of skilled labor (scientists, engineers, and technicians) ranked first on their list of priorities when choosing a location among the regions of the country. Labor costs ranked second followed by State and local taxes. Academic institutions and the cost of living were ranked fourth and fifth as regional locational attributes. Following these regional, or first stage, locational determinants were community level factors such as regulatory practices, cost and availability of land, room for expansion, good local schools and local transportation. (See Table V.2.) These second stage factors primarily influence the choice of location sites within a region.

TABLE V.1.—FACTORS THAT INFLUENCE THE REGIONAL LOCATION CHOICES OF HIGH-TECHNOLOGY COMPANIES

Rank	Regional attribute	Percent significant or very significant [1]
1	Labor skills/availability	89.3
2	Labor costs	72.2
3	Tax climate within the region	67.2
4	Academic institutions	58.7
5	Cost of living	58.5
6	Transportation	58.4
7	Access to markets	58.1
8	Regional regulatory practices	49.0
9	Energy costs/availability	41.4
10	Cultural amenities	36.9
11	Climate	35.8
12	Access to raw materials	27.6

[1] Respondents were asked to rate each attribute as "very significant, significant, somewhat significant, or no significance" with respect to their location choices. The percent of "very significant and significant" responses were added together to obtain an index of overall importance.

Source: Joint Economic Committee Survey of High-Technology Companies in the United States (Premus, 1982, p. 23).

TABLE V.2.—FACTORS THAT INFLUENCE THE LOCATION CHOICES OF HIGH-TECHNOLOGY COMPANIES WITHIN REGIONS

Rank	Community attribute	Percent significant or very significant
1	Availability of workers	96.1
	Skilled	88.1
	Unskilled	52.4
	Technical	96.1
	Professional	87.3
2	State and/or local government tax structure	85.5
3	Community attitudes toward business	81.9
4	Cost of property and construction	78.8
5	Good transportation for people	76.1
6	Ample area for expansion	75.4
7	Proximity to good schools	70.8
8	Proximity to recreational and cultural opportunities	61.1
9	Good transportation facilities for materials and products	56.9
10	Proximity to customers	46.8
11	Availability of energy supplies	45.6
12	Proximity to raw materials and component supplies	35.7
13	Water supply	35.3
14	Adequate waste treatment facilities	26.4

Source: Joint Economic Committee Survey of High-Technology Companies in the United States (Premus, 1982, p. 23).

There are several noteworthy characteristics of high-tech company locational choices. First, high-tech companies show an affinity for location sites that offer ample supplies of scientists, engineers, and technicians, preferably near a major university system. Second, unlike other businesses, high-tech locational choices appear to be quite sensitive to tax differentials among the States and regions. Third, physical proximity to raw materials and markets is of little importance to the "footloose" high-tech companies. Finally, the locational choices of high-tech companies are influenced by a wide range of community factors, such as good schools, business climate, local transportation, and land assembly costs.

It is important to note that many of the high-tech locational factors can be directly influenced by State and local expenditure, tax, and regulatory policies. This is an important finding since it suggests that States and communities have within their power the means to improve their region's environment for entrepreneurship and innovation. However, the fact that most high-tech locational attributes are a shared responsibility of Federal, State, and local governments creates a need for government cooperation and coordination. Getting the necessary intergovernmental cooperation represents a formidable political barrier in many States and regions.

The Role of Universities

The strong dependence of high-tech companies on the skilled segment of the labor force attests to the important role that universities and technical schools play in high-tech development. Universities are major suppliers of skilled labor, but, in addition, they are the primary originators of advances in basic science that ultimately lead to new products and processes. Thus, a major challenge confronting State economic planners is to simultaneously strengthen academic institutions, find ways to stimulate "spinoff" companies from university research, and increase the rate of technology transfer to existing businesses. The establishment of university-based science parks and innovation centers are examples of linkages that many States are using to strengthen university-business ties. Joint research efforts and expanded industrial affiliate programs are other important mechanisms for improving high-tech linkages. Perhaps experimenting with ways to encourage a recoupling of industry and academe is the single most important public policy innovation that is being pursued under the rubic of the "State high-tech movement."

Creating an Investment Climate

Basic research at universities, strong industry ties, and an abundance of skilled labor are not sufficient conditions to spur innovation and high-tech expansion. If major barriers to entrepreneurship are present (e.g., an onerous tax system or inadequate location sites) many potential high-tech commercial opportunities may remain unexploited. For this reason, a high-tech strategy must include efforts to improve the States' overall investment climate to complement its human capital and basic research policies. This section considers nine potential State actions to improve a region's investment climate and what high-tech executives think about the likely success of these actions.

The views of the high-tech executives on State development actions are taken from the responses the Joint Economic Committee's 1982 Survey of High-Technology Companies in the United States. Table V.3 lists nine of these State actions included on the survey and the percent of the high-tech executives that felt that the action would have a "very significant or significant" impact on business (investment) expansion. An analysis of the survey results for each of the potential State actions follows:

TABLE V.3.—THE IMPACT OF ALTERNATIVE STATE POLICY ACTIONS ON THE EXPANSION OF HIGH-TECHNOLOGY INDUSTRIES

Rank	Alternative state	Very significant (percent)
1	Cut redtape	84.9
2	Reduce taxes	84.5
3	Offer financial incentives	79.8
4	Improve community attitude	55.5
5	Train labor	48.8
6	Reduce lost time during inspections	47.6
7	Improve cultural amenities	38.6
8	Improve recreational facilities	36.1
9	Procure resources from local businesses	28.6

Source: Joint Economic Committee Survey of High-Technology Companies in the United States.

Cut Redtape

The high-tech executives apparently view regulatory redtape as a significant barrier to State and local economic development. Over 80 percent of the high-tech executives in the Joint Economic Committee Survey listed "cut redtape" as likely to have a "very significant or significant" impact on business expansion.

There are sound theoretical reasons why high-tech companies view the regulatory burden as a serious impediment to expansion. First, high-tech companies operate at the early, or expansion, phase of the product life cycle. It is at this stage of business expansion that the regulatory maze has its greatest opportunity to stymie company expansion. In fact, the "capture theory" of regulation suggests that the established companies view the regulatory process as a means of protecting their established markets against would-be competitors.[4] Being outside of the political process, the young, high-tech companies are much more likely to view regulations as an obstacle to expansion.

Second, high-tech companies generally operate on a short product life cycle because of technological obsolescence. Technological obsolescence is a fact of life for many of the high-tech companies. They must continually innovate, or engage in competitive innovation, to maintain or expand their market shares. Thus, to be profitable in a rapidly changing technological environment, the commercial exploitation of high-tech investments must proceed relatively rapidly. Time delays associated with obtaining zoning changes, design approvals, and other regulatory redtape can lengthen the investment period and add significantly to risks. Lost time can reduce the ability to raise the necessary large sums of venture capital to exploit new commercial opportunities.

Third, unnecessary regulatory requirements can significantly alter the entrepreneurial nature of the free enterprise system.[5] Valuable entrepreneurial resources must be diverted to meeting regulatory requirements. The loss of these entrepreneurial resources is particularly critical to high-tech companies that operate at the early, or expansion, phase of the product development cycle. For these reasons, the regulatory burden can act as a significant barrier to high-tech expansion, explaining the high priority given to regulatory relief by high-tech executives.

Finally, the location of high-technology investments is also affected by regulatory requirements. Over 70 percent of the high-tech executives felt that State and local regulations had at least some impact on locational choices. About 35 percent of the high-tech executives rated State and local regulations as having a very significant or significant impact on locational choices.

States can take several steps to relieve the regulatory burden. One would be to establish a regulatory review board to examine ways to more efficiently manage the regulatory process, to review the impact of regulation on the State's business climate, and to recommend the necessary regulatory changes. Another action might be to institute "one-step permitting" as is used in Washington and Oregon. Another important approach might be to provide regulatory relief to new and expanding businesses, particularly in urban "enterprise zones."

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[4] George J. Stigler, "The Citizen and the State," Chicago: The University of Chicago Press, 1965.

[5] Murray L. Weidenbaum, "The High Cost of Government Regulation," Challenge, December 1979, pp. 32-39.

Cut Taxes

The high-tech business community apparently places tax policy high on its agenda of recommended State actions to encourage business investment. In particular, over 80 percent of the high-tech executives listed "reduce taxes" as likely to have a very significant or significant impact on the expansion of business investments.

There are several reasons why taxes are important to high-tech companies. First, taxes cut into corporate cash flow and make it more difficult to pay the wages and salaries necessary to compete for scientists, engineers, technicians, and other key personnel. In fact, in a recently conducted National Science Foundation survey, high-tech companies listed lack of financial resources to pay competitive salaries as their largest problem.[6] For companies that depend upon scientific inputs to remain competitive, the tax burden can be a serious constraint to expansion. Second, taxes can significantly reduce the flow of available venture capital for high-tech expansion. A recent Government Accounting Office (GAO) study found that the availability of capital is quite sensitive to government tax policies. In particular, the GAO found that high taxes (particularly the capital gains tax) reduced the flow of available venture capital to the risk-oriented high-tech companies.[7]

A State policy of reducing business taxes and raising personal taxes is not likely to bring much relief. Personal taxes can likewise adversely affect the emerging high-tech industries. The skilled segment of the labor market, upon which high-tech companies so keenly depend, is the segment that is most affected by high personal tax rates. However, in a seller's market the State tax burden is likely to show up on the wage demands of scientists, engineers, technicians and other personnel. By reducing corporate cash flow, the high-tech companies would be in a less favorable position to attract the necessary labor skills.

The high rating given to "cut taxes" should not be taken literally as a recommended State action without regard for other factors. The need for support services such as adequate funding for universities, good schools, airport facilities, and good local transportation—and expenditures to satisfy the noneconomic objectives and social responsibilities of State government—must also be considered. It does suggest, however, that unnecessary government spending, administrative inefficiencies and an overly generous commitment to social programs, by leading to higher taxes, can undermine the vitality of a State's entrepreneurial community.

Offer Financial Incentives

Providing financial incentives is by far the most widely used development tool at the State and local level. Most States have the enabling legislation to permit the use of tax incentives such as property tax abatement and investment tax credits. The objective of these tax incentives is to raise the after-tax rate of return on new investments. Also, most of these same States have capital subsidy schemes such as loan guarantees, industrial development bonds, and direct loan programs. The objective of the capital subsidy schemes is to lower the cost of capital to businesses expanding within the State.

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[6] William L. Stewart and Norman W. Friedman, "Problems of High Technology Firms," National Science Foundation, Special Report (NSF 81-305), December 1981.

[7] U.S. General Accounting Office, "Government-Industry Cooperation Can Enhance the Venture Capital Process," Report to Senator Lloyd Bentsen, Joint Economic Committee, U.S. Congress, Washington, D.C., Aug. 12, 1982.

The effectiveness of these policy instruments to stimulate business expansion depends upon the net interest elasticity of the State's investment demand schedule. The fact that 80 percent of the high-tech companies felt that financial incentive schemes will have a "very significant or significant" impact on business expansion, suggests that they view the investment schedule as interest elastic, or responsive to the net interest differentials among the States created by the financial incentive programs.

Apparently, financial incentives will have more of an influence over the startup and expansion decisions than they do over the location decisions of high-tech businesses. In another question, only 24 percent of the high-tech companies listed financial investments as affecting their company's location decision. The majority of the high-tech executives rated the impact on financial incentives on their company's location decisions as insignificant. Thus, it would appear that the high-tech executives view traditional financial incentives as influencing startups, expansions, and investment in new technologies. Plant relocations are largely unaffected by subsidies, implicit or explicit.

Improve Community Attitudes

The high-tech executives listed "improve community attitudes" as the fourth most important action that States could undertake to encourage high-tech expansion. The ability of a region to assimilate new ideas and adjust to change can be a significant factor in the expansion of innovative companies. Resistance to technical change can come from top corporate management, lower echelon managers and the public at large. Unions, too, all too frequently view technical change as the enemy of labor; yet, ironically, technical change is the major source of growth in real per capita income, jobs, and leisure.[8]

Train Labor

An apparently effective development tool pioneered in South Carolina and used throughout the Sunbelt region is the "preemployment training program" concept.[9] The typical preemployment training program offers specific training to prospective employees of new or expanding companies within the State. There is little or no cost to the business or the trainee. The State employment agency generally is utilized to screen prospective employees who must agree to enroll in the preemployment training program as a condition for employment. The corporation endorses an agreement of intent to hire those individuals that successfully complete the training program. Thus, the company benefits by having a trained labor force with the skills required on the day the new facility is to open.

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[8] Clinton C. Bourdon, "Labor, Productivity, and Technological Innovation: From Automation Scare to Productivity Decline," Christopher T. Hill and James M. Utterback, eds., Technological Innovation for a Dynamic Economy, Pergamon Press, 1979, pp. 222-254.

[9] Michael McManus, "Work Training Need Not Be Costly," The Northern Perspective, 1982.

The low rating given to training labor suggests that high-tech companies do not look to these programs as a source of the labor skills required in their operation. The generally short nature of preemployment training programs, typically 13 weeks or less, is unsuited to the labor market requirements of the high-technology companies. However, the high rating given to skilled labor (technical workers, engineers, and scientists) in locational choices in Table V.2 suggests that technical schools, and community colleges, as well as universities, have an important role to play in providing a high-tech environment for innovation and technology transfer to local and regional businesses.

Reduce Lost Time During Inspections

State inspection procedures ranked relatively low in terms of significant State action, but, nonetheless, there is some room for improvement. Over 38 percent of the high-tech executives viewed improved inspection procedures as likely to have a very significant impact on business expansion. Government regulations that affect the expansion of businesses is another matter. As discussed previously "cut redtape" was listed as one of the most important actions States could take to encourage capital formation and innovation.

Improve Cultural/Recreational Amenities

State policies to improve cultural and recreational amenities and facilities to attract industry were rated by the high-tech companies near the bottom of the list of alternative State action. This finding contradicts the common belief that high-tech employees, because of their generally higher education levels, will place a premium on those locational sites that offer attractive cultural and recreational opportunities.

Procedure Resources From Local Businesses

Finally, a "buy local" policy to stimulate high-tech development received very little support from the high-tech executives. The theory behind "buy local" campaigns is straightforward. To the extent that State purchases are switched to in-State suppliers, local demand will increase, allowing more jobs to be created.

While on the surface it may appear that this approach has some merit, it, nevertheless, suffers from several fatal flaws. First, State governments would be subsidizing inefficient suppliers, but even if this can be overlooked, few jobs are likely to be created because firms in the high-tech industries sell in national and international markets. In this case, product demand would be shifted from one State to another with little or no impact on labor demand. Thus, it is very unlikely that this policy would have any significant impact on the interstate distribution of high-tech companies. Even if it did, however, other offsetting factors will occur. In an open, interdependent system, high-tech businesses in other States will demand similar actions against out-of-State suppliers. The net effect will be higher costs for all State and local governments from inefficient procurement policies, and no perceptible impact on the spatial distribution of high technology jobs.

THE EXPERIENCE OF UTAH, NORTH CAROLINA, AND PENNSYLVANIA

The normative question of what States should do to improve their climates for innovation and technological change was discussed in the previous section. This section examines the strategies of several States to determine what States are actually doing to "target the process of innovation." In particular, the strategies being implemented in the States of Utah, North Carolina, and Pennsylvania to induce innovation and high-tech growth are examined. The discussion is based upon testimony presented before the Joint Economic Committee on August 9, 1984, by Gov. Scott M. Matheson of Utah, Gov. Dick Thornburgh of Pennsylvania, and Donald S. Beilman, President of the Microelectronics Center of North Carolina.[10] The testimony of Peter Brennan, professional consultant, presented at that hearing, is also used as a basis for this evaluation.

The policy strategies of States participating in the "high-tech movement" generally place major focus on overcoming shortages of skilled labor, technological barriers to product development and improved process technologies, and financial barriers to business expansion. The strategies of Utah, North Carolina, and Pennsylvania were chosen for indepth analysis because their approaches are representative of what other States and regions are doing to encourage technological innovation.

Utah

Utah's high-tech approach places major emphasis on policies that augment the supply of scientific, engineering, and technical workers. This is being accomplished through expanded university degree programs, the creation of centers of excellence, and by improving science and mathematical training in elementary and secondary schools.

Utah's population growth rate is the highest in the Nation; hence, the need to accelerate job expansion is of paramount importance to this State. Utah's four universities and two technical institutions, all located along the Wasatch Front, the 100-mile corridor stretching from Logan on the north to Provo on the south, have been instrumental in meeting the skilled manpower needs of high-tech firms in Utah.

The U.S. Department of Labor-funded pilot program, the Wasatch Front Enterprise Center, assists new business owners in learning about the labor and management skills they need in their new business venture. This center bridges the gap between the technical and management skills of the entrepreneur. The Wasatch Front Private Industry Council, which is associated with the center, is a cooperative effort between government and private business to train and place qualified individuals in the dynamic labor market. The Federal Job Training Partnership Act programs are placed under the jurisdiction of the Department of Community and Economic Development to ensure that the resources are well coordinated to provide the skills necessary for State economic development.

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[10] "State Strategies To Improve the Climate for Innovation and Economic Growth." Testimony presented before the Joint Economic Committee, U.S. Congress, Aug. 9, 1984.

Utah has a science adviser and an advisory council on science and technology to advise the Governor and the legislature. The purpose is to encourage technological innovation in both private and public sectors. The State's university system fosters a mutually beneficial partnership between the university and high-tech industry. A case in point is the College of Engineering at the University of Utah, which has become a center for high-technology research. Government and private funding for this effort totals $8 million annually. The College of Engineering is now ranked in the top 20 nationally in research support.

Besides providing facilities to develop technology, both Utah State University and the University of Utah have established innovative channels to transfer new products to private use. The University of Utah's Patent and Product development office actively recruits firms to license university technology. An interesting aspect of this program is that the university will accept equity interest in a company as payment for a license. This has enabled 20 small startup companies to obtain licenses since 1981.

The University of Utah has also developed a research park to facilitate the interaction of university knowledge with industry. The park represents an investment of $85 million. One of the residents of the park, the Utah Innovation Center, was established in 1977 with funds from the National Science Foundation. In return for an equity position, or a share of interest in a firm's technology, the Center provides venture capital, management assistance, technical library office space, and secretarial and legal services. Since 1982 when the Federal funding ended, the Center has become a private firm in conformity with the National Science Foundation's hope that it would evolve into a self-sustaining entity.

The State has developed a number of financial innovations to induce economic growth and high-tech development. A case in point would be the research and development tax credit enacted by the Utah Legislature in 1974. A blanket exemption of the sales tax on new manufacturing equipment is currently being considered. Utah is also developing a capital budget system which is indicative of a strong commitment to improving their public infrastructure.

Utah actively participates in the Federal Small Business Revitalization Program which makes SBA 503 loans and Urban Development Action grant funds available to the States. Of the 34 States involved, Utah ranks first, on a per capita basis, in the amount of money placed with small businesses.

Another institution which encourages the establishment and growth of new high-technology businesses is the Utah Technology Finance Corporation. The newly created corporation has received money from both public and private sources, including Federal and State funds, and it provides seed money in several areas including research contracts, program grants, equity investment, convertible loans, and venture financing. The corporation also has a State Small Business Innovation Research Program (SBIR) similar to the

Federal SBIR and will provide research and development finance to meritorious applications only partially funded by Federal programs.

North Carolina

This State has a long, successful tradition of pursuing high-tech growth. The effort began formally in 1959 with the opening of the Research Triangle Park. Its 5,500 acres are dedicated to a mixture of research, service, and high-tech activities. The Research Triangle Foundation, which is responsible for the park development, stresses the importance of a close relationship between the parks occupants and Duke University (8 miles away), North Carolina State University (14 miles away in Raleigh), and the University of North Carolina (12 miles away in Chapel Hill).

IBM, Northern Telecom, Burroughs, Monsanto, and Data General are among the major corporations now located in the park, giving the Research Triangle Park world class status.

Recent efforts have been taken by North Carolina to expand and improve technology-related research, education, and training programs throughout the State. These efforts can be broadly grouped under the following headings:

1. Modern technical education—$80 million was earmarked for the State's community college system. This system includes 58 campuses across the State. Ninety percent of the population is within commuting distance of one of these community colleges and 600,000 citizens participate each year in their educational programs. Programs are continually updated to include the skills necessary to support new technology industry.

2. Higher education and training—$27.4 million was earmarked for the university engineering and computer science buildings. The major goal is to improve the quality and quantity of output of graduate programs in science and engineering at North Carolina universities.

3. Applied research—$32 million has been allocated for the North Carolina Biotechnolgoy Center and the Microelectronics Center of North Carolina.

The Microelectronics Center of North Carolina has established itself as a major national resource for modern electronics by combining the resources of five universities (Duke University, North Carolina A&T University, North Carolina State University, University of North Carolina at Chapel Hill and University of North Carolina at Charlotte) and the Research Triangle Institute.

The State encourages the startup of new firms through three basic mechanisms: a State initiative, increased Federal support, and private investment.

The State initiative includes the establishment of a Technical Development Authority (TDA) which helps local communities establish incubator facilities to nurture new firms. Last year (TDA's first) TDA invested $225,000 of State money in five new ventures.

The State helps North Carolina firms participate in the Small Business Innovation Research (SBIR) Program. In the first round of the program, North Carolina firms won 18 awards amounting to $778,265. The award ratio of 1 in 6, is one of the best in the Nation.

Public and private investment in research and development in North Carolina is over $600 million per year. These investments in R&D are expected to result in increased spinoff companies which would in turn stimulate additional use of technology and further economic growth.

Pennsylvania

This State has a unique program called the "Ben Franklin Partnership" which represents a consortium of business, labor, research universities, and other higher education institutions, and economic development groups. This young program is designed to move advanced-technology initiatives out of the laboratory and into the shop floor to create new jobs and business opportunities. This program has centers at Lehigh University, Pennsylvania State University, Philadelphia's University City Science Center, and jointly at the University of Pittsburgh and Carnegie-Mellon University.

During this fiscal year, Pennsylvania hopes to exceed $100 million in public and private financing committed to the largest annual State technological innovation program in the Nation. In addition, about $12 million in venture capital has been attracted to Ben Franklin supported programs. Pennsylvania now has in operation the largest number of small business incubators of any State in the Nation. One of the main reasons for the success of this program is the catalytic private sector acting as its driving force. Private sector representatives serve on the policy and advisory boards of each center; volunteering services, facilities and equipment. These representatives provide a significant amount of matching funds and help to set the priorities for specific research and development work.

Federal and State funds earmarked for technology training, include computer literacy in the schools and the upgrading of mathematics and science skills of the public school teachers.

An estimated $180 million will be made available over the next 3 years for new investment due to the recent 10 percent reduction in the corporate net income tax in this State.

The Pennsylvania Industrial Development Authority (PIDA) serves the needs of business expansion by offering low-interest loans. In addition, it also provides additional incentives for firms with fewer than 50 employees.

A Pennsylvania capital loan fund was created from funds of the State-controlled Federal Appalachian Regional Commission (ARC). This year $15 million in State funds was earmarked to supplement ARC dollars over the next 3 years.

A recent State law which greatly improves venture capital availability, is one which permits the use of up to 1 percent of the State public school employees retirement funds for venture capital investments. This initiative is expected to provide up to $100 million in additional venture capital in the State. Utah, California, and a number of other States have recently passed similar legislation.

This spring, Pennsylvania voters approved a $190 million bond issue to fund a variety of new initiatives, such as providing loan assistance to employees who wish to buy out firms that otherwise would close or move elsewhere and increasing aid to the Pennsylvania Minority Development Authority.

In general, the Utah, North Carolina, and Pennsylvania experiences suggest that the "State high-tech movement" represents a fresh approach to economic development by many States and regions. The State high-tech strategies examined in this chapter are based upon a number of guiding principles which include:

1. An emphasis on building links between industry and academe;
2. A strong commitment to improving the quality of human capital through education, training, and research;
3. A recognition that research and advanced technology can help to improve the competitiveness of existing firms and industries, and develop new firms from existing industries;
4. The belief that the private sector must have a lead role in the design and implementation of high-tech strategies;
5. An awareness that most new job growth will come from existing businesses and industries within the State; and
6. Recognition that a successful economic development program will require a long-term commitment to improving a State's climate for entrepreneurship and innovation.

A number of proponents of the now defunct national industrial policy movement have argued that States, not the Federal Government, should have responsibility for developing a "targeted" industrial policy for the States. If all States pursue industrial targeting, the sum of their efforts could be called a State implemented national industrial policy. Recently, the State of Rhode Island launched its version of a centralized "targeted" industrial policy and it was resoundly defeated by the voters. Yet, while the Rhode Island experiment was failing, Utah, North Carolina, and Pennsylvania, and many other States and regions, were winning popular support for their innovation strategies. Their strategies, unlike the Rhode Island example, emphasize "targeting the process of innovation" and shun strategies that would have State and local government officials "pick winners and losers" in a gigantic new industry subsidy game.

SUMMARY AND CONCLUSION

An analysis of the locational requirements of high-tech companies revealed the locational environment of high-tech complexes, such as the Silicon Valley in California and Route 128 in the Boston region. Many States and regions are attempting to create an innovative climate similar to that which is found in these two premier high-tech centers. For example, analysis of the high-tech strategies of Utah, North Carolina, and Pennsylvania revealed that the primary focus of State innovation strategies is on removing labor market, technological, and financial barriers to innovation and business expansion.

The States have not given up their well-entrenched practices of "smokestack chasing and deep locational subsidies." Economic studies have repeatedly found that locational grants and other job pirating strategies have little or no effect on the course of regional development. To the extent the States merely stamp their old development policies with a high-tech label and attempt to relocate the Silicon Valley or Route 128, they will not be successful. "Persuading an established company to move from one location to another is a zero-sum game with no net gain for the Nation," said one Governor at the 1984 National Governors' Conference. In the words of Peter J. Brennan:

> Understanding the distinction between transplanted and innovative technology is an essential key to well planned area development programs. The first brings prosperity but not roots; the second is seed for a future built on products that do not exist or are yet a tiny factor in the economy.[11]

The experiences of Utah, North Carolina, and Pennsylvania suggest that State and regional development strategies are undergoing fundamental change. The focus of their high-tech strategies is inward on policies to create an innovative environment that is conducive to business startups, expansions, improved process and product technologies, and the development of new industries. While the efforts of individual States and regions may seem to be insignificant, in the aggregate they are substantial.

To the extent that the States and regions are successful, in their new endeavors, the Nation stands to gain substantially from having an improved climate for entrepreneurship and innovation. States are pursuing inward-looking innovation strategies because they are beginning to realize that most future job growth within their region will come from the expansion of existing firms and from new entrepreneurial startups. In this regard, the proper role of the Federal Government is to pursue a "hands off" policy regarding any attempt to use its vast resources to direct State and local development efforts. This would include eliminating Federal Government support for State and local industry subsidy and job pirating schemes, and curbing the abuses of tax exempt industrial development bond programs.

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[11] Peter J. Brennan, Testimony before the Joint Economic Committee, U.S. Congress, "State Innovation Strategies," Aug. 9, 1984, p. 41.

VI. VOICE OF THE ENTREPRENEURIAL COMMUNITY

Silicon Valley in California and Boston's Route 128 are vibrant centers of high technology that have captured world attention. What are the reasons for the tremendous success, economic growth, and prosperity that have characterized these laboratories of high-tech development? Can these same successes be achieved elsewhere? To find the answers to these questions, the Joint Economic Committee held hearings and toured plants in Silicon Valley on August 27 and 28, 1984, and at Route 128 in Boston, on August 30 and 31, 1984. A great deal was learned about the entrepreneurial spirit, attitude, management style, motivational and incentive influences, and, most relevant to this study, public policy recommendations for advancing the cause of entrepreneurship in the United States.

Testimony was heard from 27 witnesses, and tours were made of 10 plants and facilities.

In this chapter we summarize the findings from those hearings, probing into the heart and soul of entrepreneurship and innovation. This chapter discusses the underlying motivational forces and incentive structures that have both created this flowering of high-technology development and that continue to nurture it. Most important, the chapter discusses important public policy issues that affect entrepreneurial development. Public policy recommendations are presented which can fuel entrepreneurship, not only in Silicon Valley and Route 128, but in other areas of the United States as well. These include not only positive recommendations for aiding entrepreneurship, but recommendations for removing barriers to entrepreneurship.

To understand the heart of entrepreneurship and innovation, one must first get into the mind of the entrepreneur. The entrepreneur is a peculiar being, peculiar in a creative and dynamic way. What motivates the entrepreneur?

RISK

A vast majority of the entrepreneurs that founded the many high-tech firms in Silicon Valley and Route 128 were previously employed in successful, established high-technology and electronics firms in the same locality. In fact, the corporate history of these regions can be pictured as an extensive genealogical family tree where one firm has given birth to another or several firms and, in turn, these firms produced their own offspring. There must be something about the entrepreneur that enables him to leave the security of current employment and venture into the insecure and precarious world of starting a business on his own. The core of the entrepreneurial spirit is that the entrepreneur is willing to take risks. The entrepreneur of today resembles the American pioneer of yesterday; willing to leave behind a safe and stable existence for the chance for great personal achievement and growth and, in the process, to expand and enhance the well-being of the surrounding community.

Success, however, is not the typical outcome. In fact, failure is most often the case. Dr. C. Lester Hogan, Director and Consultant to the President, Fairchild Camera & Instrument Corp., in testimony in Silicon Valley, estimated that only 5, and at the most 10, out of every 100 firms founded in Silicon Valley succeed.

Hogan went on to point out that failure is a necessary purifying agent in our free enterprise system. The 90 or 95 firms that fail "should fail." It ensures that the most productive and efficient resources will percolate to the top and will be utilized to the greatest social benefit. Less productive resources will be rechanneled into more suitable uses. Although the entrepreneur may fail, the entrepreneur is no failure. The willingness to take risks, whatever the outcome, enriches the character of the risktaker, adds to his or her wisdom and is the impetus for the evolution and strength of the American economy. Moreover, one cannot justify the potential large rewards to both the venture capitalist and the entrepreneur if one takes away the risk of failure.

INNOVATION AND CREATIVITY

Entrepreneurs, particularly those in the field of high technology, are innovators. They forever search for more efficient processes and procedures, and for new and better products. The histories of Silicon Valley and Boston areas are filled with instances where individuals, feeling frustrated and creatively stifled, defected from their former company and sought to establish a new firm in order to develop some idea of theirs and bring it to fruition. The result has not only been the proliferation of new high-tech companies and products, but also the establishment of new markets and new industries. For example, the semiconductor industry gave birth to one of the most significant and revolutionary developments in high technology in recent years, the microprocessor. At the heart of every weapons system, telephone, or electronic toy, is the microprocessor. In fact, the microprocessor opened up a marketplace of personal and small-business computers. In sum, without the entrepreneur's willingness to take risks and drive for innovation, the success stories of Silicon Valley and Boston's Route 128 may have never materialized.

These characteristics—a relish for risk, innovation and creativity—acting alone, however, are not sufficient reasons for the great proliferation of new high-tech companies and their phenomenal growth. The willingness to take risks does not necessarily mean those risks will be taken; and the drive for innovation may not result in a move toward initiation. There needs to be a structure of legislative and regulatory incentives and a system of rewards that can encourage and facilitate action on the part of the entrepreneurial community. These public policy issues are discussed in the last half of this chapter.

ROLE MODELS

Role models play an important part in encouraging many entrepreneurs to establish new firms. They provide valuable lessons in management, marketing, and production techniques. The accumulated experience of the Hogans, the Noyces, and the Sporcks enabled many entrepreneurs to build on the foundation of these giants in the development of their own businesses. While the necessity of risktaking and creativity is vital to initiate a company and should not be understated, the need for building on the previous training and experience of others cannot be overstated.

EMPLOYEE-MANAGEMENT RELATIONS

One key factor responsible for the rapid development of technological innovation in Silicon Valley and Route 128 has been a distinctive and enlightened employee-management relationship. In fact, such a relationship has made these high-tech firms literally factories of innovation. There exists a unique blend of incentives and rewards which, combined with a stimulating work environment, have created phenomenal rates of productivity and technological innovation. As W.J. Sanders, Chairman and CEO of Advanced Micro Devices, said, "We believe that many of our sister high-tech companies are not only on the leading edge of technology, but also on employee relations."[1]

What is it about this type of relationship which breeds innovation and, in addition, has made the companies in these two regions some of the best companies in the country to work for?

The reasons are due, in part, to the nature of the high-tech industries. Such industries are extremely competitive and firms must constantly innovate and develop new products in order to stay alive. High-tech firms must provide incentives to attract and maintain a talented work force and to continually stimulate innovation and productivity.

To a certain degree, the competition in the marketplace for talented employees is as fierce as in the marketplace for the high-tech products themselves. In fact, in Silicon Valley, because of close proximity between high-tech firms, there is a not so facetious joke that an employee, dissatisfied with his or her job, can simply drive into the next parking lot and work there instead. Employee shifts are almost that easy and that common.

INNOVATION AND WORK ENVIRONMENT

The unique and progressive work environments in high-tech firms play a key role in their ability to stimulate innovation. In fact, innovation, to a certain extent, is the ultimate goal of the work agenda.

The basic underlying theme of the high-tech work atmosphere is, what can be called, the "human factor." After all, innovation cannot be mined from the ground, but is found in the minds of people. An atmosphere of innovation, therefore, must be oriented toward people, because people produce innovation. It is this emphasis on the human factor that contrasts the high-tech work environment with that of other industries. As Charles Sporck, President and Chairman of the Board of National Semiconductor said, ". . . people are the whole ballgame in our business." [2]

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[1] U.S. Congress, Joint Economic Committee, "Climate for Entrepreneurship and Innovation in the United States," Field Hearings in Sunnyvale (Silicon Valley), CA, Joint Economic Committee, 98th Congress, 2d sess., Aug. 27-28, 1984, p. 72.

Typical of the work environment of high-tech firms is a high degree of informality. There are no private offices (instead you see partitioned work space), no executive bathrooms, no reserved parking spaces, nor any of the usual amenities of a traditional corporate pecking order. While on the surface these may seem trivial, nevertheless, they symbolize an important attitude. That attitude is an emphasis on innovation, rather than corporate structure, a recognition that it is the hired hands—the engineers and scientists on the firing line—that are the creators of the firm's products, and often those products are simply ideas.

It is believed that the most fertile atmosphere for innovation is one where there is open communication and a free flow of ideas up, down, and sideways, and where each employee feels that he plays a role in the decisionmaking processes of the company. Sandra Kurtzing, Chairman and CEO of ASK Computer Systems, Inc., explains, "The atmosphere is collegial where all ideas are debated and the best ideas emerge. The result is a true team effort. The people orientation also goes beyond the tangibles. Employees act like owners because . . . they are owners."[3]

While top management continues to be the ultimate decisionmaking body, management and production decisions are not dictated from the top down. Rather, they are a synthesis of the free exchange of ideas in which every employee may have some input.

In addition to the informal work environment, many firms in Silicon Valley and Boston have built facilities which make working in these companies just plain enjoyable. Many have built gymnasiums and recreation parks which enable employees to unwind and relax so that they can free their minds for more creative and innovative ideas.

VENTURE CAPITAL COMMUNITY

The venture capital community plays an extremely important role in the proliferation and growth of high-tech firms. It provides the necessary capital to initiate numerous startups and supplies crucial additional capital for growth and development. In some ways, the entrepreneurial community and the venture capital community are inextricably intertwined.

First, venture capitalists do not merely provide money. In most cases the venture capitalists also take an active part in the management of the company. In an emotional and intellectual sense, they become coventurers. Venture capitalists often provide valuable management and business know-how and experience that can be critical to the success of the company, knowing that ventures of this sort are not short term. It often takes 5 years before any return at all on investment is generated and it may take even 10 years before a venture capitalist can sell his or her investment. Arthur D. Little of Narragansett Capital Corp. explains this long-term commitment of venture capitalists: "We have a company now that is doing about $70 million of business. We had to put money into that company 17 times before it finally showed a profit. We did question our judgement from time to time on that one, but you don't have that market that is going to give you the quick profit. So you have to have that long range patient view."[4]

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[2] Ibid., p. 68.

[3] Ibid., p. 113.

Second, venture capital provides financial leverage for high-tech, high-growth companies. The typical startup company finances its initial investment by the use of debt instruments, such as bonds, loans, etc. But debt financing provides little benefit for new high-growth, high-technology firms. High-technology firms need substantial amounts of equity capital in order to fund research and to develop new products. A large pool of capital during those early years is crucial to a high-tech firm's viability. Debt financing would require that dividends and interest be paid out of that pool of vital initial capital, thus draining the company of critical financial resources from the beginning.

Venture capital helps the high-tech firms avoid this problem. Venture equity capital is long-term, direct investment in a company whose return is much delayed and depends on the growth and success of that company. During these first few important years, venture capital can supply the funds necessary for research and development, so crucial to the longrun viability of the company.

The venture capitalist's motives are not purely altruistic. The rewards from a winning investment can be very large indeed. True, there is substantial risk, and an entire investment can be lost, but a few good winners can usually more than compensate for the losing investments.

One interesting phenomenon in Silicon Valley and Route 128 is that often the venture capitalists will seek out talented entrepreneurs or hot ideas for investment, rather than wait for entrepreneurs to seek him or her out. At the Joint Economic Committee field hearing examples were cited where venture firms actually took part in the entrepreneurial act itself. They had ideas and assembled the talent, the money, and the organization to launch a new business. However, the typical case is the opposite—the entrepreneurs seeks out the venture capitalists.

FEDERAL POLICY AND THE ENTREPRENEUR

At the Joint Economic Committee hearing in Silicon Valley and Boston's Route 128, a number of public policy issues surfaced that have an important bearing on the ability of the entrepreneur to succeed in promoting technological and economic advancement. As might be expected, most of these issues center on tax policy. This section addresses these public policy issues that are of greatest concern to the entrepreneurial community.

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[4] Ibid., p. 310.

Capital Gains Tax

The most important of the tax provisions affecting entrepreneurs is the Capital Gains Tax. Because of the large risks involved in establishing a startup, there needs to be a strong incentive to induce the potential entrepreneur to take that risk. While a low-tax on capital gains may provide some incentive, a low absolute tax rate is not sufficient. The critical factor is the tax on capital gains relative to the tax on personal earned income. It is this differential between these tax rates which induces the entrepreneur to leave his or her secure, regular salaried income and attempt a high risk venture. The lower the rate on capital gains relative to personal earned income, the greater the incentive to accept the risk and to initiate the startup.

There have been some important changes in capital gains taxation in recent years. Under the 1969 Tax Code, the tax rate on capital gains ranged between 35 and 49 percent, the actual rate depending on eligibility for exclusions and alternative tax provisions. The 49 percent top rate on capital gains, under the 1969 code, was little different from the 50 percent top rate on personal earned income (which had been lowered from 70 percent to 50 percent in 1969).

Because the top tax rates on earned and investment income were virtually identical, there were little or no incentive to invest in young and growing companies. As a result, the number of new startups dwindled and the pool of venture capital almost dried up in the 1970's. In 1975, the total new private capital directed to venture capital firms was a paltry $10 million.

In 1978, the capital gains rate was lowered to 28 percent by raising the exclusion to 60 percent and lowering the inclusion to 40 percent (40 percent times 70 percent equals 28 percent). Then, in the Economic Recovery Tax Act of 1981, the capital gains tax was lowered to 20 percent as a result of dropping the top rate on unearned income to 50 percent (40 percent times 50 percent equals 20 percent). Thus, beginning in 1978, and more strongly in 1981, the investment pattern in new companies reversed itself. In 1978, the amount of total private capital increased each year thereafter and by 1983 it had jumped to $4.1 billion. Venture capital funds have been flowing profusely ever since.

Thus, the differential between capital gains rates and personal earned income tax rates is an important incentive mechanism to entrepreneurs. Prudent public policy would dictate that this differential be maintained if not increased further.

The R&D Tax Credit

The R&D Tax Credit has also had a significant impact on the growth of high-tech firms. High-tech industries are extremely competitive and, in turn, this fierce competition places tremendous pressure on firms to constantly innovate and develop new products. Constant innovation, however, requires continuous research. Research is imperative to the survival and growth of these dynamic companies. The R&D Tax Credit enables these firms to devote more of their earnings to research for technological innovation and the development of more products.

Unfortunately, the R&D Tax Credit provides little benefit to brand new startup companies. In general, startup companies do not make taxable profits in their early years; hence, the credits can do little to provide incentives for R&D. After the initial startup period, though, the R&D Tax Credit can be extremely beneficial to rapidly growing companies and can serve as a powerful incentive for research and development. In fact, the R&D credit provides proportionately greater benefits for rapidly growing smaller companies than for larger, established companies with slower growth. This is due to the nature of the tax credit provisions. The R&D credit is a function of *increased* R&D expenditures over a base period amount. Since small, rapidly growing companies make greater percentage *increases* in research and development spending relative to larger companies, they receive proportionally greater benefits from the R&D credit.

Witnesses at the Silicon Valley and Route 128 hearings recommended several changes to make the R&D Tax Credit more useful. First, reestablish the "safe harbor leasing" concept that would allow companies to sell the benefits received from the tax credit. In this way, small startups could benefit from the R&D credit in their early years. Second, the R&D tax credit schedule only allows use over a very short period of time. In order to provide greater incentives for long-term research and development, the schedule should be lengthened to enable firms to derive benefits from the credit over long base periods. Third, eliminate the rolling base restriction and base the measurement of R&D increases eligible for the credit on 1982 to 1984 average expenditures. Fourth, permit tax deductions for contributions of equipment for teaching science in universities, colleges, and vocational institutions. (There is already a provision for equipment donated for scientific research.) Finally, and most importantly, the R&D credit is scheduled to expire on December 31, 1985. Simple prudent answer: Make it permanent.

Incentive Stock Options

Undeniably, the most important incentive mechanism that high-tech firms use to both attract personnel and encourage productivity are incentive stock options, or "ISO's." ISO's are particularly important in recruiting needed management and engineering personnel. These skilled people are in great demand and, therefore, require strong incentives to persuade them to leave secure employment in an established firm for an insecure future in a new one. In a majority of the high-tech firms in Silicon Valley and Route 128, it is not uncommon for ISO's to be extended to all employees in a company, thus appealing to the entrepreneur spirit in everyone. Each employee is a partial owner in the company, and as a result, each person in the firm has a stake in its future growth and success. This is a great boon to productivity in high-tech firms. The greater the rate of growth the company experiences, the greater will be the appreciation of the firm's stock and, consequently, the greater the value of the option. Thus, each employee has an incentive to be as productive as possible and contribute his or her fullest to the success of the company.

Another reason ISO's have contributed to the success of these high-tech firms is that ISO's serve as an effective personnel recruiting mechanism, without using up previous cash needed for research and development for promoting long-term growth.

According to Bureau of Labor Statistics data, high-tech firms are not always high-paying firms. While wage scales are slightly above the national average for the total private sector, they are below, sometimes substantially below, wage scales in many industry groups—motor vehicles and equipment, petroleum refining, paper and allied products, primary metal, construction, mining, and a host of others.

These high-tech firms would never be able to attract the necessary talent were it not for the ISO's and other noncash benefits, such as medical and dental insurance programs.

There are some problems, however, with ISO's that need correction. First, the attractiveness of ISO's is severely diminished by a ceiling of $100,000 (at fair market value) on the allowable amount of options that can be granted to an employee in 1 year. This $100,000 annual ceiling is arbitrary and creates a disincentive for employees to participate in the ISO program. Second, the "spread" between the exercise price of the option and the fair market value is treated as a tax preference item in calculating the alternative minimum tax. Under these provisions, someone exercising an option can be subject to a 20 percent tax on a paper profit and, in addition, be subject to capital gains tax at the time of sale. The result is double taxation of what may very well be a capital loss. Third, ISO's must be exercised in the order of sequence in which they were granted. This rule greatly reduces the benefit of ISO's, particularly if the exercise price of the options granted earlier exceeds the current market value or those granted have an exercise price lower than fair-market value.

Alexander d'Argeloff, President of Teradyne, Inc., of Boston, poignantly expresses the concern of the entrepreneurial community concerning the problems of the incentive stock options: "Putting it all together . . . we've been crushed under the weight of endless tinkering and our publicly held companies have lost the benefit of one of the most brilliant and least costly incentive schemes ever devised." [5]

The appropriate policies are self-evident. Eliminate or raise the artificial ceiling on the allowable amount of ISO's that can be granted per year. Amend the Tax Code to eliminate the option "spread" as a tax preference item. Last, amend the Tax Code to delete the provision concerning sequential ordering of exercising options.

Additional public issues that are of interest to the entrepreneurial community, and came up for discussion in the JEC field hearings, are the following:

High-technology products have been an important component of U.S. exports in a market that is extremely competitive. It is imperative that U.S. high-tech exports be allowed to flow freely if we are to maintain our competitive edge. Various factors, however, have frustrated our ability to export these high-tech products and have put the United States at a disadvantage in the world market place.

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[5] Ibid., p. 276.

One problem is the administration of export licenses. Waiting periods between requests for licenses and the ability to finally export have been excruciatingly long. Witnesses in Silicon Valley told painful stories of sales lost to other countries because other countries were able to act quickly and deliver their products speedily. This is an administrative problem. The Commerce Department must undertake intensive efforts to reduce the time between export license applications and the granting of licenses.

Another problem relates to our sensitive national security. While we need to place restrictions on high-tech exports with military value, the restrictions often prevent export of nonsensitive high-tech products, which pose no threat to national security. The problem is the vague definition of military sensitivity. William Bowman, Chairman of the Board of Spinnaker Software Corp. of Cambridge, MA, illustrates this point. He said, "It takes as much effort for us to export 'Facemaker,' which is an electronic version of 'Mr. Potatohead,' as it does another customer to export software that builds missile trajectories." [6]

We are not critical of the stand of our military establishment in blocking high-tech exports having military value. But nonsensitive exports should not be caught in the crossfire. The definitions of "sensitive" high-technology products need careful analysis.

A third factor has been an extremely strong dollar on foreign exchange markets. Although a strong dollar is often a healthy sign, it has created problems for export industries, particularly high-tech industries. Because of the strength of the dollar, our high-tech products have become more expensive relative to high-tech products of other countries. This is an issue that goes far beyond the scope of this study, but it does need national attention.

Finally, the need for a talented and adequately trained labor force is crucial to the growth of high-tech industries. Because of the relatively low math and science skills of American students, compared to some of our foreign competitors, and because of the inadequate supply of needed technical talent, U.S. firms rely heavily on skilled, foreign talent. For example (and a common example), the vice chairman of Intel Corp. said that 75 percent of their engineers and scientists are foreign born. Witnesses at the field hearings said that recent efforts in Congress to require foreign students, who have graduated from American universities to leave the country for 2 years before returning, would have a traumatic effect on high-tech industries. However, there are some important immigration policy considerations that have to be weighted against this specific concern of the high-tech firms.

CONCLUSION

There can be no question that the vigorous spirit of entrepreneurship in Silicon Valley and Route 128 in Boston has provided the necessary impetus for the economic success of these regions. In the recent spirited discussions of a national industrial policy, the voice of the entrepreneur has not been drowned out. The Silicon Valley and Boston successes were not planned. They are the direct result of a free enterprise system at work. In order to release its full potential, our free enterprise system must be coupled with an incentive structure that rewards risk and accepts failure. These should be the proper policy guidelines.

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[6] Ibid., p. 272.

Our vibrant free enterprise system and spirit of entrepreneurship and innovation should dictate the direction of economic development in this country, not some shortsighted bureaucratic planning board, as called for by the industrial policy advocates. If Silicon Valley and Boston's Route 128 provide any indication of the direction of our economy, it is clearly onward and upward.

VII. SUMMARY AND RECOMMENDATIONS

This study concludes with a summary of research findings and a discussion of public policy recommendations. The analysis and recommendations are based largely upon a series of Joint Economic Committee hearings and studies during 1983-84 period. The Committee heard from numerous business leaders, government officials, and leading economists on issues and public policies that affect industrial innovation, technology transfer, and the entrepreneurial process. Committee staff studies on high-tech firm location decisions, robotics industrial policy, Federal procurement policies, and the Nation's venture capital markets have been published on these topics.

SUMMARY

This current study effort focuses on the Nation's overall climate for entrepreneurship and innovation. The vital role played by the entrepreneur in economic growth and technological innovation is stressed. The study examines how public policies impact the entrepreneurial process in America, and what the Government's role should be in fostering an improved environment for economic growth and technological innovation. A basic conclusion of the study is that many of the shackles that stifled entrepreneurial activity in the past several decades have been removed, at least partially. As a consequence, America is now experiencing an economic rejuvenation in its old and new industries as a result of a vibrant entrepreneurial community. Entrepreneurial expansion is broad based and can be found in old as well as new industries.

Entrepreneurs are defined in this study to include all risktakers in society who have the organizational skills and the means to assemble resources and technology to exploit new economic opportunities that are not generally apparent to other decisionmakers. Risk bearing, organizational skills, and foresight are the key attributes of entrepreneurs.

Entrepreneurship cannot be taught but it can be nurtured by public policies that improve the climate for innovation. Some recent public policy changes that are contributing to the current entrepreneurial activities are:

1. The rapid growth of venture capital and other forms of risk capital resulting from recent public policy innovations, such as the 1978 and 1981 capital gains tax reductions, and improvements in regulations governing the investment behavior of pension funds.

2. The complete turnabout in inflationary psychology after 1980 from one of high inflationary expectations to one of low inflationary expectations.

3. Deregulation of many domestic industries such as trucking, financial services, communications, and the airlines, resulting in many new entrepreneurial opportunities.

4. Recent changes in patent regulations to encourage technology transfer from Federal Government funded basic research by giving universities, small businesses, and not-for-profit organizations title to inventions.

5. Passage of the Stevenson-Wydler Act of 1980 which places greater emphasis on technology transfer from research in Federal Government laboratories, agencies, and departments.

6. Substantially lower personal and corporate tax rates as a result of the Economic Recovery Act of 1981, including a substantial simplification of depreciation schedules.

7. A new macroeconomic management philosophy in Washington which emphasizes stable growth in aggregate demand to reduce policy uncertainty and promote overall stability in the economy.

8. Continued strong Federal Government support for basic research at universities and in government laboratories.

9. Continued strong public policy resistance to domestic protectionists pressures in spite of a strong dollar and large trade deficits.

While these policies have helped to stimulate and sustain the current surge in entrepreneurial expansion and investment in the economy, the job is not complete. The current challenge is to continue the policies that are in place and working, eliminate or improve the policies that are in place but are not working, and initiate new policies to overcome remaining technical, labor market, and financial barriers to economic growth and innovation.

The importance of technological innovation to economic growth is stressed throughout the study. Technological innovation enters the economy in the form of new products and processes that increase productivity and improve the quality of life. Economic growth occurs as a result of entrepreneurial decisions to employ technology, capital, and labor in new combinations or in increasing amounts.

Technology exerts a powerful force over economic growth by strengthening the product competitiveness of industries and by raising productivity. Expanded international and domestic market opportunities result from an improved cost structure, product quality, and better organization relative to other nations competing in world markets. Moreover, additional market opportunities result from higher incomes associated with productivity growth, which allow for additional domestic economic expansion. If labor markets are flexible and real wages are allowed to adjust, and if government pursues appropriate human capital and resource development policies—including policies to improve the functioning of labor markets—the net result will be a rate of net job creation sufficient to meet the needs of all Americans willing and able to work.

The study emphasizes that innovation is a process that occurs in old and new industries. It undergirds and strengthens the basic foundation upon which economic progress depends. Innovation occurs in the public and private sectors and in the manufacturing and nonmanufacturing sectors. It results from the application of new ideas to organizing economic relationships and solving economic problems. Above all, innovation is a process of economic change; it is not the outcome of economic change. Indeed, an innovation policy is one that should emphasize a "level playing field" upon which entrepeneurs in small and large, and new and old, companies compete to achieve their desired outcomes.

The analysis began by discussing the evolving nature of American capitalism. In the past decade or so, the American economy has undergone dramatic structural adjustments. As a consequence, today's economy is different from the economy of the late 1960's and 1970's. A before and after analysis revealed that today's economy is more: (1) energy efficient, (2) international, (3) service oriented, (4) technologically sophisticated, and (5) internationally competitive.

Not only has the structure of the American economy changed; the entrepreneurial character of the economy has changed as well. One consequence of increasing global competition, shorter product cycles and the emerging high-tech sectors has been an increased emphasis on product quality, service, and improved process technology in business planning. American businesses, while not ignoring shortrun concerns, such as stock prices, are rapidly shifting emphasis to longrun strategies such as market position, the role of technology, and dynamic competition.

While current economic events warrant optimism over the longrun competitiveness of the American economy the study nevertheless found several potentially serious deficiencies in the Nation's overall climate for entrepreneurship and innovation, including:

1. Saving and investment as a percent of gross national product in the United States is considerably below that of most other advanced industrial nations. The strong preference for current consumption over future consumption, reinforced by U.S. tax policy, remains as a major barrier to capital formation and technological innovation in the United States.

The U.S. Tax Code provides a heavy bias in favor of current consumption. In particular, the double taxation of saving and dividend income has created a large wedge between the rate of return of investments (approximately 12 percent) and the rate of return on saving (approximately 6 percent). Also, interest deductions on loans to finance consumer durables and purchases by credit cards provides a tax incentive to consume a larger proportion of current income. The result is a rate of capital formation for the Nation that is below the rate of capital accumulation that would occur if capital markets equated the public's preferences for current and future consumption at the margin.

2. Because the rate of capital formation is comparatively low, the United States' ability to reap the major benefits of technological innovation is also comparatively low. Many other nations—with higher rates of capital formation—are able to incorporate new technological innovations into their manufacturing and nonmanufacturing sectors at a faster rate than U.S. industries. This finding is partially attributable to the fact that in a dynamic economy the demand for new technological innovation is dependent upon the overall rate of capital formation.

3. High real interest rates are a serious barrier to long-term U.S. capital formation, productivity growth, and industry competitiveness. The recent tax reductions have significantly increased the after-tax rate of return on saving and investment but the large Federal deficit will continue to drain investment and risk capital away from entrepreneurial investments as the economy progresses through the mature stages of the economic expansion.

4. While the U.S. economy generally leads the world in basic research, commercial R&D in the United States as a share of total R&D spending is lagging. A continued expansion of commercial R&D concomitant with a higher rate of capital formation will be necessary to modernize U.S. manufacturing and restore its competitiveness in world markets.

5. The process of technology transfer in the United States has been, and remains, in spite of recent improvements, an important barrier to technological innovation. Technological innovation in the United States is a highly specialized process, but the various components of this process are haphazardly connected. Basic research is largely housed in American universities and funded by the Federal Government. Private industry, however, has primary responsibility for "picking and nurturing" the commercial fruit that germinates from new insights into nature, provided by basic research. As a result of a gap between industry and academe, the road for the development of a new technology starting from idea formation to a full fledged technology is long and uncertain. In the 1950's and 1960's, the gradual drifting apart of academe and industry served to lengthen the gap and increase uncertainty.

While recent years have witnessed a healthy recoupling of academe and industry, the formation of industry-university ties is only in its fledgling stage. Many barriers—imagined and real—between the university system and industry must be removed to improve the ability of American industry to maintain, and improve its technological lead in commercial markets—a must to sustain longrun competitiveness.

6. The U.S. is currently blessed with a high quality stock of human capital and dynamic labor markets that offer the economy a degree of flexibility and dynamism unparalleled in the world. Unfortunately, the quality of the educational processes has been allowed to erode in the past several decades, and the educational needs of disadvantaged youth and displaced workers have not been fully addressed. Without strong Federal Government support for human capital improvements, especially in the sciences and engineering, America's technological edge will be increasingly difficult to maintain and perpetuate. The entrepreneurial community will suffer as well since technological innovation is a major source of new entrepreneurial opportunities.

7. While the Committee hearings found substantial evidence that State and local governments in recent years have been adopting new policies aimed at "targeting the process of innovation," large sums of money are still being spent on job pirating and industrial location schemes which detract from the Nation's entrepreneurial climate. Because they result in higher State and local taxes, without providing direct national benefits, the overall effect of location-

al subsidy schemes is a lower overall rate of private sector investment.

State and local governments have major responsibility for education at the elementary, secondary, and the university levels. The quality of the academic environment that they provide is an extremely important factor in the Nation's innovation process.

Also, State and local governments control much of the Nation's public infrastructure—roads, highways, ports, and airways—that is necessary to promote private sector expansion. State and local government regulatory policies also affect the speed and cost of business development and the willingness and ability of financial institutions to assume a risky investment portfolio.

8. Finally, the Federal Government invests heavily in the development of applied technology to meet the mission needs of Federal Government departments and agencies. The Department of Defense, National Institutes of Health, and the National Aerospace and Science Administration are the largest government consumers of technology. Many of the Government labs perform both basic and applied research, the results of which often have potential commercial applications.

The Committee discovered through its hearings that the process of technology transfer from government laboratories is cumbersome and largely inefficient, despite recent important improvements resulting from the Stevenson-Wydler Act of 1980. In particular, the highly centralized, bureaucratic structure of Federal departments and laboratories mitigates against technology transfer in many cases.

The result of these deficiencies is an economy suffering from slow productivity and economic growth, notwithstanding the fact that the United States is generally acknowledged to lead the world in many areas of basic research. The essential problem is the lack of incentives within the private sector to turn new inventions into new and more efficient, products, processes, and other technologies. To overcome these problems, this section advocates policies to raise the rate of capital formation, improve technology transfer from government laboratories, improve university-business linkages, and accelerate commercial R&D efforts.

POLICY RECOMMENDATIONS

The policy recommendations of this study are based upon an extensive analysis of the relationships between government and the entrepreneurial community. An important assumption throughout the analysis is that government cannot and should not attempt to direct entrepreneurial activities in the economy, because government expenditure, tax, and regulatory policies impact on the entrepreneurial process, creating an improved climate for entrepreneurship and innovation is rightfully the responsibility of national public policy.

The policy orientation of this study is long run. The study is concerned with the process of growth and development of the American economy, and with identifying the appropriate Federal role in promoting an improved climate for entrepreneurship and innovation.

It is important to note that the private sector cannot work efficiently without government, because the government performs many functions that are vital to the entrepreneurial process: research, defense, macroeconomic management, social policy, maintaining a legal framework, and trade policies are examples of government inputs into the entrepreneurial process. It is equally important to note that if government oversteps its bounds in carrying out its proper functions in dynamic capitalism, market inefficiencies will occur and economic growth will be impaired.

The policy recommendations of this study are grouped into the following categories: capital formation, commercial R&D, entrepreneurial policies, human capital, university linkages, technology transfer, New Federalism policies, and domestic and international competition.

Capital Formation

Capital formation occurs when investors invest in new plant equipment. In an environment of investment growth, technological innovation is stimulated. It is generally easier to incorporate new technology into new machines and physical facilities than it is to upgrade existing technologies and plant and equipment. For this reason, an accelerated rate of capital formation stimulates entrepreneurial demand and demand for new products and process technologies.

The study recommends the following government actions to raise the overall rate of capital formation:

1. *Remove or reduce the burden of double taxation of saving and investment.*—The current Tax Code offers a number of incentives to increase saving and capital formation. Individual Retirement Accounts (IRA's), accelerated cost recovery, investment tax credits, and lower marginal tax rates (the maximum rate is currently 50 percent) are all credited with contributing to the strong investment climate in the United States in recent years. Nevertheless, public policy uncertainties, the large Federal deficit, marginal tax rates that are still too high, and high real interest rates remain as barriers to capital formation.

To remove these barriers to capital formation the study recommends:

2. *Monetary and fiscal policies that avoid shortrun fine tuning and place major focus on long-term economic growth.*—Removing policy uncertainty is an important factor in stimulating capital formation and innovation. This is because the most significant single factor encouraging or inhibiting entrepreneurship is the health and predictability of the macroeconomy. An economy characterized by large swings in aggregate demand does not provide the entrepreneur with a stable growing market that is conducive to new business growth.

3. *A gradual reduction in the Federal deficit to reduce real interest rates and allow the value of the dollar to find its longrun value.*—To reduce the deficit, the study recommends a longrun strategy of holding Federal Government expenditures to no more than 18 percent of gross national product.

4. *Lower marginal tax rates through tax base broadening.*—A modified flat tax rate program could provide a significant stimulus to overall capital formation. The 1981 and 1982 tax programs made a significant step forward in reducing excessive taxation on capital investments, but they introduced differentials in effective corporate tax rates by type of investment. Tax base broadening would reduce the distorting effects of differential tax rate burdens. By lowering tax rates, overall capital formation would be stimulated.

5. *Expand the current IRA program to allow individuals to defer a larger amount of their otherwise taxable income.*—Increasing IRA exemptions to $5,000 per household would go a long way to removing the heavy burden of double taxation on saving and allow the market to increase the Nation's rate of capital formation.

Commercial R&D

The Federal Government should pursue policies to encourage commercial R&D, but it should avoid substituting government "targeted" strategies for reliance on market signals. Maintaining a healthy basic research community, providing incentives for commercial R&D, and improving linkages between basic and applied research activities can provide a viable alternative to direct government involvement in commercial research. It should be noted, the private sector will not invest optimally in applied research unless inventors are given adequate patent protection and other problems of nonappropriation are overcome. Appropriation problems result in a divergence, at the margin, of social and private benefits resulting from research. When this occurs, the market will fail to optimize investment and research opportunities.

The study recommends the following actions to encourage commercial research and technological innovation:

6. *The Federal Government should maintain strong support for basic research at American universities.*—Since basic research precedes applied research, maintaining strong Federal Government support for basic research is important. Technological innovation relies heavily on the progress and findings of basic research. Notwithstanding that basic research is becoming more and more valuable to commercial firms in its original form, it is still relatively long term in its scope. The traditional Federal role in supporting basic research, therefore, needs continuing support. The current Administration and the Congress have placed increasing emphasis on basic research, at a time when other budget increases are being curtailed. This priority on basic research is well placed, and will help keep this nation at the forefront of world technology.

7. *Congress ought to make permanent the current R&D tax credit and extend its base to include software development important to the application of technology within firms.*—At the present time, the R&D tax credit is not applicable to computer software R&D. This serious omission needs to be corrected if the R&D credit is retained in its present form. Additionally, the credit makes a distinction between the purchase of equipment for a university for the purposes of research, and for teaching purposes. Since this distinction is often impossible to make, and since there is a close correla-

tion between a university's teaching and research missions, this distinction should be eliminated.

8. *Preserve the tax advantage of R&D partnerships, particularly when they are used to encourage joint research efforts.*—The growth of R&D partnerships has been a significant vehicle for raising the level of commercial research in the United States. Also, as will be discussed later, the R&D partnership approach has promoted technology transfer and collaborative research efforts between industry and academe.

9. *Efforts to adopt antitrust laws to current economic realities need to be continued.*—The study applauds the current Administration and the Congress for their efforts in adapting the enforcement of antitrust laws to modern conditions. However, changes in the basic antitrust legislation are needed. The Sherman, Clayton, and Federal Trade Commission Acts, which still comprise the Nation's basic antitrust legislation, were signed into law more than 70 years ago. Last year, the Congress passed the National Cooperative Research Act. This law made substantial improvements in the climate for industrial basic research, by clarifying the standard for competing firms so that they could benefit collectively from cooperative research. That law, however, was part of a broader proposal, the National Productivity and Innovation Act, which would also have removed barriers in the patent laws, among others. Additional attention needs to be given to refining these proposals in the 99th Congress.

Entrepreneurial Policies

An overall strategy to increase economic growth through stimulating saving, investments, and technological innovation ought to be accompanied by policies to facilitate structural changes within firms and among industries in the economy. For this reason an economic growth strategy ought to incorporate among its components an entrepreneurial policy.

Entrepreneurial activities flourish in a time of economic change. Indeed, they are the internal mechanism by which the economy is transformed and shaped by changing external and internal forces, such as international competition, technological change, and changes in consumer preferences. Providing an environment whereby capital formation and technological innovation are flourishing as discussed, is the most significant action Government can take to improve the overall entrepreneurial climate.

Nevertheless, beyond these policies a number of additional initiatives would be helpful:

A significant proportion of entrepreneurial activities consists of seeking technological opportunities that others overlook or fail to fully recognize for their full commercial potential. A strong Federal commitment to basic research in the advanced sciences, discussed previously, is necessary to create new high-tech entrepreneurial opportunities.

Entrepreneurial high-tech opportunities are too risky for institutional investors to consider, but fortunately, venture capital markets have expanded to fill the void caused by the increasing institutionalization of financing markets. A recently published JEC study on "Venture Capital and Innovation" found that networking and the availability of venture capital is a significant factor in the overall climate for technological innovation. Both the number and quality of high-tech entrepreneurial deals was found to increase as a result of expansion in venture capital following the 1978 and 1981 capital gains tax reductions.

Because of the importance of venture capital and other forms of risk and investment capital to the entrepreneurial process, the study recommends the following actions:

10. *Preserve the capital gains tax differential in the Tax Code to encourage risktaking.*—The Kemp-Kasten bill would provide this needed incentive while at the same time it would greatly simplify the Tax Code and lower marginal tax rates on income. For these reasons, the study recommends the adoption of the Kemp-Kasten program and it rejects the Treasury plan and the Bradley-Gephardt plan as they now stand.

11. *Improve incentives in the Tax Code to help entrepreneurial companies attract the needed talent.*—Being able to attract talent is the number one problem of high growth, young entrepreneurial companies. To overcome this problem, the study recommends changes in incentive stock options as an inducement to entrepreneurial growth. Specifically, the ceiling, sequencing and tax preference provisions should be eliminated or modified.

12. *Also, the tax exempt status of employee educational fringe benefits should be maintained in the Tax Code.*

Human Capital

The progress of science and technology, and its potential for improving our standard of living, depend in the first instance on society willing to invest in the human resources that underlie our technological preeminence. Yet the state of today's science and engineering education, starting at the secondary school level, leaves much to be desired. Some have proposed a new Morrill Act. Other, less sweeping, proposals call for higher standards in the teaching of science and mathematics in secondary schools, and changes in the treatment of gifts of equipment for teaching. (See above.) The study notes that the current Administration and the Congress have placed special importance on the upgrading of basic science and math skills in the primary and secondary schools and in the university system. These efforts to improve human capital should be continued and reinforced with new initiatives that:

13. *Provide scholarships and other incentives for brighter students to enter the science and engineering fields in college and beyond.*

14. *Establish a nationwide program to make nonsubsidized loans available to all college students without regard to family circumstances.*—The principal and interest would be collected by the IRS through withholding when the loan recipients enter the labor market.

University Linkages

The Federal Government ought to pursue policies to encourage and promote stronger linkages between academe and industry. Policies in place that are already encouraging these linkages include preferential tax treatment of R&D partnerships, granting universities title to patents resulting from federally funded research, NSF funded university research centers, the inclusion of 65 percent of contract services with universities in the incremental R&D tax credit base, and tax deductions for equipment grants to universities for purposes of research.

The study recommends that these policies be maintained and the following few initiatives be implemented:

15. *Extend the R&D tax credit for contributions of equipment for the teaching of science in universities, colleges, and vocational schools.*

16. *Encourage Federal departments and agencies to engage in collaborative research with universities and industry.*—The collaborative performance of the basic research needed to support Federal department and agency mission requirements could lead to the emergence of "centers of excellence" within academe, strengthen the Government laboratory system, and speed the commercialization of new technologies.

17. *Encourage joint university-industry research through a continuation of preferential tax treatment of R&D partnerships when the university is a partner in the joint venture.*

Technology Transfer

Federal Government laboratory research is legally available for use by the public. In practice, however, there are few incentives to utilize Federal patents and other research findings. This stems from certain provisions of patent laws, and the large amount of resources required for tracking and following through on Federal research.

Under the mandate of the Stevenson-Wydler Technology Innovation Act of 1980, Federal laboratories have made significant efforts to inform the public about developments in their research programs. However, for the most part, technology developed in Federal laboratories remains underutilized in the private sector.

To improve technology transfer, the study recommends the following:

18. *Decentralize authority and responsibility for technology transfer by making technology transfer a Federal laboratory responsibility, subject to review by Federal departments and agencies.*—The study recommends that the Office of Research and Technology Applications be a full-time staff position, with responsibility for networking with the business community, defining conflict of interest rules, acting as legal council for laboratory employees, and establishing policies for rewarding employees for successful technology transfer programs.

19. *Establish a Commission for Technology Transfer to develop operating guidelines and procedures for laboratory directors, engineers, and scientists to work collaboratively with universities and the private sector.*

20. *Federal Laboratory Consortium—a voluntary association of Federal laboratories—should be designated as the primary coordinating organization for promoting technology transfer.*

New Federalism Policies

In recent years, State and local governments have made encouraging strides in reorienting their development strategies to focus on the process of innovation. Many States are changing their tax, regulatory, and expenditure policies to encourage entrepreneurial activities and technological innovation. This revamping of development practice is largely in response to competition pressures among the States and regions for economic development and jobs.

The study recommends a Federal Government "hands off" policy with regard to the design and implementation of State and local development programs. However, the Federal Government has a role in discouraging those State and local activities that detract from the Nation's overall climate for entrepreneurship such as job pirating and industry locational subsidy schemes. Industrial development bonds are frequently used as locational inducements at the State and local levels.

To overcome this deficiency and to encourage State and local governments to focus on the process of innovation, the study recommends the following:

21. *Discourage the use of industrial development bonds by eliminating their tax exempt status.*

22. *The New Federalism policy of consolidating block grant funds and returning responsibility for regional economic development to the States ought to be continued.*—The Federal Government ought to maintain financial responsibility for those programs such as welfare and training displaced workers, in which there is a national interest.

Domestic and International Competition

Finally, because competition among firms and industries is vital to the entrepreneurial process and to the economic growth and prosperity of the Nation, a vigorous policy to promote competition, at home and abroad, must receive top priority in the decades ahead. In particular:

23. *The deregulation of domestic industries should remain as a national economic goal.*

24. *Open and free trade policies ought to be strongly supported and fought for by the Administration and the Congress.*

25. *Efficiency in the granting of export licenses must be improved so that American firms can get an early start in competing in international markets.*

26. *Foreign nationals with skills in occupations where there are shortages should be allowed to remain in the United States for a time.*

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